7037(195)

NASA SP-7037(195)

**Aeronautical Engineering**
A Continuing Bibliography with Indexes

NASA SP-7037(195)
January 1986

# Aeronautical Engineering
A Continuing
Bibliography
with Indexes

NASA SP-7037(195)
January 1986

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# ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

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NASA SP-7037(195)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY
## WITH INDEXES

## (Supplement 195)

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A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in December 1985 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 389 reports, journal articles, and other documents originally announced in December 1985 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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# AERONAUTICAL ENGINEERING

## A Continuing Bibliography (Suppl. 195)

JANUARY 1986

## 01

## AERONAUTICS (GENERAL)

**A85-48567**

**THE COMPOSITE TECHNOLOGY OF A MAIN ROTOR BLADE**

R. A. DOE and D. HOLT (Westland Helicopters, Ltd., Yeovil, England) IN: Fibre reinforced composites '84; Proceedings of the International Conference, Liverpool, England, April 3-5, 1984 . London, Plastics and Rubber Institute, 1984, p. 9.1-9.16.

The composite materials system, structural design and fabrication methods of the Lynx/Westland 30 helicopter composite main rotor blade are discussed. Attention is given to the accommodation of aerodynamic, blade weight, rotor balance, blade stiffness, and centrifugal force constraints, and to the manufacturing hardware employed in composite laminate tape-laying operations. O.C.

**A85-48570**

**ASPECTS OF CERTIFICATION OF CIVIL AIRCRAFT STRUCTURES IN COMPOSITE MATERIALS**

J. W. BRISTOW (Civil Aviation Authority, London, England) IN: Fibre reinforced composites '84; Proceedings of the International Conference, Liverpool, England, April 3-5, 1984 . London, Plastics and Rubber Institute, 1984, p. 17.1-17.12. refs

The recent past has seen a marked increase in the application of composite materials to structures in civil aircraft - some examples are cited. This paper discusses the issues raised in the airworthiness certification of such structures from the viewpoint of the Civil Aviation Authority. An outline of the requirements that have to be met and the associated guidance material that has been recently evolved is given. Author

**A85-48571**

**STRUCTURAL PLASTICS IN SPORTING AND GENERAL AVIATION AIRCRAFT**

J. FRAY (British Aerospace, PLC, Manchester, England) IN: Fibre reinforced composites '84; Proceedings of the International Conference, Liverpool, England, April 3-5, 1984 . London, Plastics and Rubber Institute, 1984, p. 18.1-18.10.

An historical account is given of the development of comparatively high performance primary structure design and fabrication techniques by sporting aircraft manufacturers, on the basis of the gradual improvement of glass-reinforced plastic materials. Extensive use is noted to have been made of foamcore sandwich primary structures, which may ultimately lead to the rapid and simple assembly by amateur constructors of entire airframes composed of only a few large sandwich panels. These technologies have recently been extended to executive aircraft. O.C.

**A85-48573**

**THE FIRST BRITISH DESIGNED AND BUILT COMPOSITE SAILPLANE**

J. C. RIDDELL (J. C. Riddell and Associates, England) IN: Fibre reinforced composites '84; Proceedings of the International Conference, Liverpool, England, April 3-5, 1984 . London, Plastics and Rubber Institute, 1984, p. 20.1-20.10.

Attention is given to evaluation methods recently applied to the composite materials used in the construction of a sailplane, proceeding from material properties and test structures to the proof loading of wing and tail panel prototype components and the ultimate strength structural testing of wing spars and fuselage. The materials employed were fiberglass woven fabrics, balsa wood sandwich panel cores, and isophthalic polyester resins for laminate and gel coat applications. O.C.

**A85-49089**

**ADVANCED TECHNOLOGIES PROMISE SALES BOOST FOR GENERAL AVIATION AIRCRAFT**

J. C. LOWNDES Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Sept. 23, 1985, p. 71, 73, 75 (5 ff.).

The implementation of advanced aviation technologies, developed by NASA and aircraft manufacturers, in the design of new aircraft is discussed. Wings and fuselages designed for natural laminar flow and the utilization of the strength and weight advantages of composite materials in aircraft design are described. Canard and winglet aerodynamics are also being applied to new aircraft designs. The improvements in measuring natural laminar flow and the advantages of the laminar flow airfoil are examined. The use of graphite epoxy, filament winding, and low-temperature curing resin in fuselage designs is explained. Some manufacturers have utilized flying scale models instead of wind tunnel tests to obtain basic stability and control data; the use of clay models is discussed. Examples of aircraft which were developed from these technological advances are presented. The development of a turbulent airfoil, an electromagnetic impulse deicing system, and a propfan installation is discussed. I.F.

**A85-49127#**

**SUNRISE, THE WORLD'S FIRST SOLAR-POWERED AIRPLANE**

R. J. BOUCHER (Astro Flight, Inc., Marina del Rey, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 840-846. Previously cited in issue 16, p. 2277, Accession no. A84-35214. refs

**A85-49553**

**DETERMINING OPERATING AND SUPPORT COSTS WITH USAF DO56 MAINTENANCE DATA COLLECTION SYSTEM**

R. S. MORRIS and B. E. BARTELS (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 197-206.

Successful users of the USAF Maintenance Data Collection System - DO56 - have resolved and reduced the often deficient data, ascertaining maintenance action rates, reliability parameters and manpower resource consumption of weapon systems (or components thereof). Northrop Corporation utilizes the data to estimate support costs. This paper will follow the development of the support cost for the F-5, from receipt of raw DO56 data, resolution of anomalies in the data, incorporation validated data into a useable data base, and finally, the computation of operating and support costs using this data. Author

**A85-49571**
**MODELING COMBAT MAINTENANCE OPERATIONS**
T. N. COOK and R. C. DINICOLA (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 390-395.

A computer model was developed to simulate helicopter maintenance operations in combat. Written in GPSS computer code, the Combat Maintenance Simulator (CMS) mathematically models a fleet of helicopters performing combat missions. Scheduled inspections, system maintenance, and repair of battle damage are performed in the course of the simulation. The user is able to specify policies with regard to deferring nonessential maintenance and repair during periods of combat emergency. Computer graphics are used to display the mission performance of the fleet under various sets of conditions. The CMS models has been used to support research aimed at reducing the maintenance workload and increasing the mission capability of Army helicopters in combat. Author

**A85-49576**
**MODELING AIRCRAFT COMBAT DAMAGE REPAIR**
D. H. KOVATCH (Vought Corp., Dallas, TX) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 440-445. refs

The development of an aircraft battle damage repair (ABDR) database, the REPAIR estimator model, and a damage simulator for estimating combat damage repair times of inflight and parked aircraft is discussed. The database, which is composed of a master file and a set of library files, is to define repair estimates as a function of a damage assessment and repair concept. The means of establishing standard and nonstandard repair estimates and the effect logistics and environmental conditions have on the estimate are explained. The REPAIR estimator model was developed to assist the processing of ABDR data and provide aircraft repair times; a flow chart of the model and an explanation of how the system functions are provided. The modified SCAN aerial target description and warhead endgame effectiveness program was used as the damage simulator model. The simulator, which predicts the probability of an aircraft surviving an attack by a missile, is described. I.F.

**A85-49584**
**SQUADRON MAINTENANCE AND REPAIR TECHNIQUES (SMART) VALIDATION TEST REPORT**
H. E. ROSENBERG and B. L. BERSON (Lockheed-California Co., Burbank, CA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 510-512.

The purpose of this study was to evaluate the effectiveness of Lockheed's Squadron Maintenance and Repair Techniques (SMART) as a troubleshooting aid. Seven Naval enlisted personnel, ranging in experience levels of 0 to 5 years, served as the test subjects. The study was conducted on a P-3 Environmental Control System simulator board. The results of the study indicated that both inexperienced and experienced maintenance personnel could isolate faults quickly and efficiently using SMART. SMART has demonstrated the capability to reduce not only the time required to fault isolate equipment faults, but also the amount of training and skill level requirements for maintenance personnel. Author

**A85-49585**
**F/A-18 SUPPORTABILITY ASSURANCE READINESS PROGRAM**
J. J. SINNOTT (McDonnell Aircraft Corp., St. Louis, MO) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 513-519.

The use of the Supportability Assurance Readiness Program (SARP) to evaluate the reliability, maintainability, and readiness of the F/A-18 weapon/logistics support system is discussed. SARP compares the needs of the weapons system with readiness objectives and recommends adjustments if required; the elements necessary for system readiness are presented. The development of a data base which contains the reliability and maintainability performance of each item in the F/A-18 weapon system and the support elements required is described. Three SARP simulation models which were modified to accept time-dependent variations of simulation variables are discussed. The areas of projected support problems produced from the simulation models are explained. The correction of all projected problems was necessary in order to achieve an efficient system. The F/A-18 was compared with the F-4J and A-7E; the F/A-18 proved to be a better prepared aircraft requiring less maintenance, which results in reduced operating and support costs. I.F.

**A85-49657**
**ONE-ELEVEN TRAILBLAZERS**
J. MOXON Flight International (ISSN 0015-3710), vol. 128, Sept. 7, 1985, p. 32-36.

Over the last ten years, two aircraft have been employed in England to test new ideas in avionics, navigation, and flight control. The operations conducted with the aid of the two aircraft have made it possible to a mass a vast data base of knowledge. Direct voice input has been studied, and techniques for extremely accurate terminal area navigation have been established. Other studies conducted are related to relaxed stability and sophisticated gust alleviation. The conducted projects have the objective to help the UK avionics industry to gain a better foothold in world markets. Attention is given to the improvement of communications between the pilot and the outside environment, flight controls research, the simulation of terminal area holding patterns, automatic terminal area navigation, a new processing system, and a spoiler solution. G.R.

**A85-49927**
**WEIGHT CONTROL OF COMPOSITE PARTS IN PRODUCTION**
R. GILLIAM and J. MACLENNAN (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 13 p.
(SAWE PAPER 1629)

Use of composite materials in a production environment requires methods of weight control that are unique to composite structures. Stringent controls and continued monitoring of the materials, design practices, tooling, fabrication, and repair are required. Without these controls, the weight savings associated with the use of composites can very quickly be eroded. This paper addresses the specific weight control procedures employed at Sikorsky during each phase of the development process. It gives examples of weight savings degradation that occur without these controls and the orders of magnitude of weight that can be saved in specific component areas. Author

**N85-35152*** National Aeronautics and Space Administration, Washington, D. C.
**AERONAUTICAL ENGINEERING: A CONTINUING BIBLIOGRAPHY WITH INDEXES, SUPPLEMENT 190**
Aug. 1985 140 p
(NASA-SP-7037(190); NAS 1.21:7037(190)) Avail: NTIS HC $6.00 CSCL 01A

This bibliography lists 510 reports, articles and other documents introduced into the NASA scientific and technical information system in July 1985. Author

**N85-35153#** Federal Aviation Agency, Washington, D.C. Office of Management Systems.
**U.S. CIVIL AIRMEN STATISTICS FOR CALENDAR YEAR 1984 Annual Report**
31 May 1985 44 p
(AD-A156326) Avail: NTIS HC A03/MF A01 CSCL 01B

The U.S. Civil Airmen Statistics is an annual study published to meet the demands of FAA, other government agencies, and industry for more detailed airmen statistics than those published in other FAA reports. Statistics pertaining to airmen, both pilot and nonpilot, were obtained from the official airman certification records maintained at the FAA Aeronautical Center, Oklahoma City, Oklahoma. An active airmen is one who holds both an airmen certificate and a valid medical certificate. Airmen who must have a valid medical to exercise the privileges of their certificate are all airplane pilots, control tower operators, flight navigators, flight engineers, and flight instructors. The glider and lighter-than-air pilots are not required to have a medical examination but the numbers represent only those who had a valid medical certificate. Mechanics, parachute riggers, ground instructors, and dispatchers certificates represent all certificates on record at the aeronautical center. GRA

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A85-47103**

**COMPUTED STATIC STALL OF A SUPERCRITICAL AIRFOIL**

D. M. SCHUSTER and Y. TASSA (Lockheed-Georgia Co., Marietta) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 198-202. refs

The unsteady, turbulent flowfield about a supercritical airfoil in static stall has been simulated by numerically solving the two-dimensional time dependent Navier-Stokes equations. The simulation was obtained by impulsively starting the airfoil from a zero velocity condition and then marching in time by a pre-determined time step. The Navier-Stokes equations are solved at each of these time intervals yielding a time history of the flowfield. Turbulence characteristics of the flow are obtained via an algebraic turbulence model. Results are displayed using a two-dimensional contour plotter, 'DISSPLA' graphics software and a VAX 11/780 computer. Author

**A85-47129**

**A FLOW VISUALIZATION STUDY OF THE EFFECT OF WING-TIP JETS ON WAKE VORTEX DEVELOPMENT**

J. M. WU and F. T. GILLIAM (Tennessee, University, Tullahoma) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 387-391. refs (Contract F33615-81-K-3034)

The use of discrete wing-tip jets to improve the wing performance and to modify the tip vortex roll up has been investigated. A complicated three-dimensional vortex interaction in the vicinity of the wing tip flow field becomes more clear through the flow visualization study in a water tunnel. The existence of many induced secondary vortices was discovered. This finding leads to a theoretical model for analyzing the interacting vortices flow field. Flow visualization also helped in pointing out the direction for future study. Author

**A85-47132**

**THE USE OF FLOW VISUALIZATION FOR VORTEX TRAJECTORY MAPPING**

R. C. NELSON (Notre Dame, University, IN) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 413-417. Research supported by the University of Notre Dame. (Contract F08635-80-K-0303)

A flow visualization technique employed to study the vortical wake flows on slender bodies of revolution and delta wing configurations is presented. The technique was used to investigate the leeward wake structure of bodies of revolution at large angles of attack. Both symmetric and asymmetric body vortex wakes were studied. The technique was also employed to study the leading edge vortex structure on delta wing models. Author

**A85-47134**

**QUANTIFICATION OF DOWNWASH AND GROUND VORTEX OF A LIFTING ROTOR MODEL BY FLOW VISUALIZATION TECHNIQUE**

K. WADA and H. HAYAFUJI (Meijo University, Nagoya, Japan) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 428-433.

The ground effect of a lifting rotor model of 0.08-m diameter with a constant thrust coefficient of 0.01134, a blade pitch angle of 9 deg, and no cyclic pitch control was studied in the open test section of a low-speed wind tunnel. The rotor downwash velocity and the ground vortex were visualized by using a smoke wire, a sheet of aluminum-tuft grid, and a wing sheel. An analysis of flow photographs made it possible to quantify the downwash and the ground vortex. Test results are presented in graphical form. V.L.

**A85-47144**

**VISUALIZATION STUDIES OF JET IMPINGEMENT FLOWS AT MCDONNELL DOUGLAS RESEARCH LABORATORIES**

K. R. SARIPALLI (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 503-509. Research supported by the McDonnell Douglas Independent Research and Development Program. refs

Visualization experiments were conducted in water to study jet impingement flows simulating the hover flight mode of vertical take-off and landing aircraft. The principal flow visualization technique used a fluorescent dye (fluorescein-sodium) as tracer fluid, with illumination by a sheet of light obtained by spreading a laser beam. Streak-line flow patterns were also obtained using air bubbles as tracer particles. The impingement configurations of a single jet issuing from a circular blocking plate, fountain-forming twin jets without a blocking plate, and inclined twin and quadruple jets were studied. The flow patterns in different cross sections of the flow were photographed for varying configuration parameters and jet velocities. Author

**A85-47149**

**VISUALIZATION OF THE VORTEX FLOW OVER DELTA AND DOUBLE-DELTA WINGS**

N. G. VERHAAGEN (Delft, Technische Hogeschool, Netherlands) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 652-657.

The structure of the vortex flow above and behind a sharp-edged delta wing and two sharp-edged double-delta wings has been investigated by employing a laserlight-sheet visualization technique. The investigation has been carried out at a free-stream velocity of 30 m/sec, corresponding to a Reynolds number of 1.4 million, based on centerline chord length. Author

**A85-47163#**

**ON THE ACCURACY OF BOUNDARY LAYER MEASUREMENTS IN CASCADES AT HIGH SUBSONIC SPEEDS**

M. HOEGER and H. HOHEISEL (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) IN: Measuring techniques for transonic and supersonic flow in cascades and turbomachines; Proceedings of the Seventh Symposium, Aachen, West Germany, September 21-23, 1983 . Aachen, Institut fuer Strahlantriebe und Turboarbeitsmaschinen, 1984, p. 6-1 to 6-22. refs

The accuracy of boundary layer measurements performed with flattened pitot tubes at high subsonic speeds was analyzed. The effect of Mach and Reynolds number, wall interference, probe position, and static pressure variation on the boundary layer results is investigated. Accuracy is estimated for the velocity profiles on the suction surface of a compressor cascade and a turbine cascade. A comparison of laser Doppler anemometry and probe measurements within the boundary layer of a single airfoil showed satisfactory agreement. B.J.

**A85-47164#**

### COMPARISON OF A COMPUTED TRANSONIC FLOW AND INTERFEROMETRIC MEASUREMENTS AROUND THE LEADING EDGE OF A TWO DIMENSIONAL AEROFOIL ASYMMETRICALLY MOUNTED IN A WIND TUNNEL

P. J. BRYANSTON-CROSS and J. D. DENTON (Cambridge University, England) IN: Measuring techniques for transonic and supersonic flow in cascades and turbomachines; Proceedings of the Seventh Symposium, Aachen, West Germany, September 21-23, 1983 . Aachen, Institut fuer Strahlantriebe und Turboarbeitsmaschinen, 1984, p. 7-1 to 7-15. SERC-supported research. refs

A two-dimensional numerical solution using an inviscid time marching method for the design of the leading edge profile of a transonic airfoil is compared with interferometric data obtained from image plane holograms. The comparison has been made for the whole blade profile including the trailing edge shock region. A particularly detailed analysis was made in the leading edge region where the flow is accelerated from stagnation conditions to M = 1.25 in 2 mm. The agreement between the calculated and measured flow around the airfoil section was found to be very good, and the time marching scheme adopted was found to predict with high resolution the flow around the leading edge of the blade despite a partial flow blockage. B.J.

**A85-47262**

### SOME RESULTS OF EXPERIMENTAL AND ANALYTICAL BUFFETING INVESTIGATIONS ON A DELTA WING

J. BECKER (Messerschmitt-Boelkow-Blohm GmbH, Hubschrauber und Flugzeuge, Munich, West Germany) and A. GRAVELLE (ONERA, Chatillon-sous-Bagneux, France) (International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, Apr. 1-3, 1985) ONERA, TP, no. 1985-59, 1985, 36 p.

(ONERA, TP NO. 1985-59)

Results of an investigation on the buffeting characteristics of a delta wing configuration are presented. The dynamic response on the wing of a tactical fighter type aircraft at high speed and incidence is calculated by using a semiempirical method. Separation induced unsteady pressure distributions measured on a wind tunnel model are evaluated to formulate aerodynamic excitation forces. Motion induced unsteady pressure distributions caused by harmonic roll oscillations of the model are used for a correction of aerodynamic system forces. The separation-induced buffet forces and the corrected theoretical motion-induced aerodynamic forces are established for various conditions of steady model incidence, reduced frequency, Mach number and Reynolds number. The semiempirical method is tested first by recalculation of the measured model response, and is applied to predict the buffeting of total rigid aircraft and its elastic wing. The wind tunnel measurements of this investigation were performed in a joint MBB/ONERA program in the ONERA tunnel S2 MA at Modane. Author

**A85-47269#**

### EXTENSION AND USE OF NUMERICAL PROCEDURE FOR THE THREE DIMENSIONAL UNSTEADY TRANSONIC FLOWS

P. MULAK, J. L. MEURZEC, and J. J. ANGELINI (ONERA, Chatillon-sous-Bagneux, France) (International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Rheinisch-Westfaelische Technische Hochschule, Aachen, West Germany, Apr. 1-3, 1985) ONERA, TP, no. 1985-67, 1985, 10 p. refs

(ONERA, TP NO. 1985-67)

Recently a numerical procedure has been developed at ONERA to solve the unsteady transonic flow problems under 'potential flow' and 'small perturbation approximations', in the case of the most general planform wings. The use of an Alternating Direction Implicit procedure (ADI) and a functional approach has allowed a correct approximation for the small perturbation equation with consistent boundary conditions, obtained within a very reasonable computing time. Flexible models can now be taken into consideration and flutter calculations executed. The purpose of this paper is to present such results on a supercritical wing. Comparisons with experiments and the classical linear method (doublet lattice) are made. Author

**A85-47301#**

### AERODYNAMIC MODELS FOR PROPELLERS FOR FAST AIRCRAFT [CALCULS AERODYNAMIQUES D'HELICES POUR AVIONS RAPIDES]

J. M. BOUSQUET (ONERA, Chatillon-sous-Bagneux, France) (Groupe Sectoriel Franco-Sovietique - Aeronautique, Sous-groupe Aerodynamique, Acoustique Aeronautique et Structures, Reunion, 27th, Chatillon-sous-Bagneux, France, Mar. 11-15, 1985) ONERA, TP, no. 1985-55, 1985, 24 p. In French. DRET-supported research. refs

(ONERA, TP NO. 1985-55)

Features of several models being developed to describe the aerodynamics of propellers for transonic aircraft are outlined and compared with preliminary experimental results. The interest in propfans was spurred by NASA studies which have demonstrated potential efficiency gains at performance levels comparable to turbojet-powered transport aircraft. Traditional lifting line theory models provide a basis for curved lifting line, incompressible lifting surface and three-dimensional models for the propfan configurations, which are of smaller diameter than classic propeller systems and therefore must rotate at higher speeds. The validity of the new models has been established in tests of a 1 m diameter propfan in the Modane S1 wind tunnel. It is concluded that the models are of use in defining efficient airfoil shapes for realizing the potential of propfans and also as an aid in noise reduction studies. M.S.K.

**A85-48189**

### CONTRIBUTION TO THEORY OF SIMILITUDE OF SUBSONIC FLOW

A. A. SHAGAEV (TsAGI, Uchenye Zapiski, vol. 15, no. 2, 1984, p. 1-10) Fluid Mechanics - Soviet Research (ISSN 0096-0764), vol. 13, Jan.-Feb. 1984 (1985), p. 19-30. Translation. refs

The accuracy of the rules of similitude of subsonic flows about wings with infinite and finite span is analyzed. An asymptotic estimate is presented for errors of various rules correcting for compressibility and it is shown that the error of such rules can be minimized by optimum selection of the subsonic similitude parameter and by using the exact formulation of the incompressible potential flow about affine-similar foils. A similitude rule for pressure diagrams of affine-similar foils, valid in the second approximation of the subsonic theory of slender foils, is formulated. The results of calculations using approximate rules for correction for compressibility and numerical solutions of the exact equation of the potential in the case of two- and three-dimensional flows are compared. Author

**A85-48520*#** Analytical Services and Materials, Inc., Tabb, Va.

### A STUDY OF LAMINAR SEPARATION BUBBLE IN THE CONCAVE REGION OF AN AIRFOIL USING LASER VELOCIMETRY

S. M. MANGALAM (Analytical Services and Materials, Inc., Tabb, VA), J. F. MEYERS, J. R. DAGENHART, and W. D. HARVEY (NASA, Langley Research Center, Hampton, VA) ASME, Laser Velocimetry Symposium, Miami, FL, Nov. 17-21, 1985, Paper. 9 p. refs

Laser velocimetry (LV) was used to study the nature of laminar separation bubbles in the concave region of a 1.83-meter airfoil model which was tested in the NASA Langley Low Turbulence Pressure Tunnel. Three component, coincident data from LV measurements including histograms of particle velocity, mean velocity profiles, turbulence intensity, and Reynolds stresses within the shear layer were used to determine the locations of laminar separation, transition, and turbulent reattachment. boundary-layer parameters determined from velocity profiles were used to compare the results with existing empirical relations for describing the laminar separation bubble. Author

**A85-48526*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A COMPUTATIONAL STUDY OF COMPLEX THREE-DIMENSIONAL COMPRESSIBLE TURBULENT FLOWFIELDS**

C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1461, 1462. Abridged. Previously cited in issue 17, p. 2424, Accession no. A84-37970.

**A85-48529#**

**THEORETICAL AND EXPERIMENTAL STUDY OF NONADIABATIC TRANSONIC SHOCK/BOUNDARY-LAYER INTERACTION**

G. R. INGER (Iowa State University of Science and Technology, Ames), F. T. LYNCH, and M. F. FANCHER (Douglas Aircraft Co., Long Beach, CA) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1476-1482. Previously cited in issue 15, p. 2120, Accession no. A83-34901. refs

**A85-48530#**

**A THREE-DIMENSIONAL, BLOCK-STRUCTURED FINITE ELEMENT GRID GENERATION SCHEME**

A. ECER, J. SPYROPOULOS, and J. D. MAUL (Purdue, University, Indianapolis, IN) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1483-1490. Previously cited in issue 06, p. 701, Accession no. A84-17827. refs

(Contract AF-AFOSR-80-0258)

**A85-48531*#** Purdue Univ., Lafayette, Ind.

**FLOW INSTABILITIES IN TRANSONIC SMALL-DISTURBANCE THEORY**

M. H. WILLIAMS (Purdue University, West Lafayette, IN), S. R. BLAND, and J. W. EDWARDS (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1491-1496. Previously announced in STAR as N85-18000. refs

The dynamics of unsteady transonic small disturbance flows about two-dimensional airfoils is examined, with emphasis on the behavior in the region where the steady state flow is nonunique. It is shown that nonuniqueness results from an extremely long time scale instability which occurs in a finite Mach number and angle of attack range. The similarity scaling rules for the instability are presented and the possibility of similar behvior in the Euler equations is discussed. Author

**A85-48532#**

**CALCULATION OF THREE-DIMENSIONAL FLOWFIELDS BY THE UNSTEADY METHOD OF CHARACTERISTICS**

D. L. MARCUM and J. D. HOFFMAN (Purdue University, West Lafayette, IN) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1497-1505. Previously cited in issue 06, p. 711, Accession no. A84-18095. refs

**A85-48533*#** Washington Univ., Seattle.

**MULTIPLE TRANSONIC SHOCK-WAVE/TURBULENT BOUNDARY-LAYER INTERACTION IN A CIRCULAR DUCT**

D. OM and M. E. CHILDS (Washington, University, Seattle) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1506-1511. Previously cited in issue 17, p. 2446, Accession no. A83-37220. refs

(Contract NGR-48-002-047; NGR-48-002-141)

**A85-48534#**

**THE SUBSONIC NEAR-WAKE OF AN AXISYMMETRIC SEMIELLIPTICAL AFTERBODY**

R. A. MERZ (Lafayette College, Easton, PA), C. H. YI (Union Carbide Corp., Polyolefins Div., Bound Brook, NJ), and C. E. G. PRZIREMBEL (Clemson University, SC) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1512-1517. refs

The near-wake of axisymmetric semielliptical afterbody was studied experimentally in a wind tunnel at 47 m/s using an upstream support system to minimize disturbances to the wake. The flowfield was surveyed with a variety of pressure and hot-wire probes. This paper presents the mean flowfield characteristics for the entire near-wake region. The results include static and stagnation pressure distributions as well as velocity profiles. Separation occurred at 0.38 model radii upstream of the base, while realignment was found at 0.2 model radii downstream. Centerline velocity recovery is slower than for blunt bases, but far-wake similarity was found as early as 0.4 radii downstream. The overall flowfield is heavily influenced by the wall geometry. The data presented will serve as a quantitative basis for the development and evaluation of analytical solutions. Author

**A85-48539*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**INVISCID AND VISCOUS FLOWS IN CASCADES WITH AN EXPLICIT MULTIPLE-GRID ALGORITHM**

R. V. CHIMA (NASA, Lewis Research Center, Cleveland, OH) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1556-1563. Previously cited in issue 17, p. 2427, Accession no. A84-38043. refs

**A85-48874#**

**SUPPLEMENTS TO 'THEORY OF SECONDARY FLOW IN CASCADES'**

S. OTSUKA (Nagoya University, Japan) Nagoya University, Faculty of Engineering, Memoirs (ISSN 0027-7657), vol. 36, Nov. 1984, p. 118-137. refs

The secondary flow in a two-dimensional cascade has been investigated experimentally in a high-speed cascade wind tunnel. It is shown that the direction of the wake has a definite value which is independent of the aspect ratio of the cascade when loss coefficients are low. The direction of the secondary flow was related to the direction of the mean exit flow measured by a yaw meter. The experimental results confirmed the theoretical flowcalculations of Otsuka (1977). I.H.

**A85-48875#**

**NUMERICAL ANALYSIS OF TRANSONIC FLOW AROUND A TWO-DIMENSIONAL AIRFOIL BY SOLVING FULL NAVIER-STOKES EQUATIONS**

Y.-Y. WANG and T. FUJIWARA (Nagoya University, Japan) Nagoya University, Faculty of Engineering, Memoirs (ISSN 0027-7657), vol. 36, Nov. 1984, p. 138-178. refs

An effective finite-difference scheme for solving full compressible Navier-Stokes equations was initiated by Beam and Warming. The purpose of this paper is to develop that technique and apply it to the calculations of several typical subsonic and transonic, inviscid and viscous steady flows for NACA 0012 airfoil. Part of the analysis briefly contains the derivation process of all used formulas and the empirical treatments. Inviscid and viscous flows are analyzed separately, along with associated grid formation techniques and boundary conditions. Author

**A85-48988**

### EXPERIMENTAL METHOD FOR THE STUDY OF CORNER FLOWS [METHODE EXPERIMENTALE D'ETUDE DES ECOULEMENTS DE COIN]

J. COUSTEIX and G. PAILHAS (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 39 p. In French.
(AAAF PAPER NT 84-06)

A four-wire hot-wire anemometer was devised for obtaining data on the three velocity components in corner flows such as are present at wing-fuselage joints and between rows of turbomachinery blades. The sensor is calibrated to extract the angular sensitivity of velocity values obtained. Data from the probe are analyzed statistically to extract the average velocities and the Re stresses. Details of the numerical model for interpreting the data are discussed. Sample pressure and velocity data are provided for flow passing a wing-fuselage junction. The data expose the formation of an initial nonuniform boundary layer containing cells of longitudinal vortices. M.S.K.

**A85-48989**

### THE UNSTEADY PROPERTIES OF A FLOW WITHIN A SCHEMATIC AIR INTAKE [PROPRIETES INSTATIONNAIRES DE L'ECOULEMENT A L'INTERIEUR D'UNE PRISE D'AIR SCHEMATIQUE]

P. GRYSON and J. P. FLODROPS (Lille I, Universite, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 43 p. In French. DRET-supported research.
(AAAF PAPER NT 84-09)

Experimental results are presented from wind tunnel studies of the two-dimensional vortical structures that form beyond the lip of a variable height air duct. The recirculating, divergent tunnel used had a 40 x 200 mm test channel. Two parallel, 8 mm thick flat plates, whose separation distance was controllable, were used in the studies. The effects of 20, 30, 40, and 60 mm separations were examined in flows with velocities between Mach 0.4-0.5. Interior data were obtained using pressure probes along and off the wall. Strio-interferometry was employed to generate flow visualizations. The appearance of the vortical fluctuations was found to be due to the interior pressure fluctuations. M.S.K.

**A85-48990**

### TURBULENCE IN AIR INLETS [LA TURBULENCE DANS LES MANCHES A AIR]

J. C. COURTY, C. CAMBON, and M. HAMADICHE (Avions Marcel Dassault-Breguet Aviation, Vaucresson; Lyon, Ecole Centrale, Ecully, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 42 p. In French. refs
(Contract DRET-77-410; DRET-80-552)
(AAAF PAPER NT 84-10)

A spectral approach is taken to model turbulent shear flows within air intakes at high angles of attack. The model was developed to understand the effects of longitudinal and transversal pressure gradients on the turbulence. Using wind tunnel velocity fluctuation data for the interior of a compressor as a basis, a spectral model of anisotropic homogeneous turbulence is defined, including initial and boundary conditions. It is found, after examining the experimental data, that the fluctuations will probably appear at angles of attack over 14.5 deg. The fading of the largest fluctuations will be equivalent to the global fading of the fluctuations. It is therefore recommended that subsequent studies be focused on identifying the highest magnitude fluctuations. M.S.K.

**A85-48991**

### A FINITE DIFFERENCE MODEL FOR FLOWS AROUND AN AIR INTAKE [CALCUL DE L'ECOULEMENT AUTOUR D'UNE PRISE D'AIR EN DIFFERENCES FINIES]

J. P. FAIDY (Avions Marcel Dassault-Breguet Aviation, Vaucresson, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 45 p. In French. refs
(AAAF PAPER NT 84-11)

A finite difference model is presented for simplifying the calculations necessary for designing air intake ducts for high performance military aircraft. The potential equation for a perfect fluid is written in nonconservative form in cylindrical coordinates. Account is taken of the presence of a conical object in the duct to assure flow stability in the presence of supersonic shocks. The three-dimensional geometry of the intake and cone is treated in terms of a series of longitudinal cross-sections in rotation from the center of the cone. Sample calculations for supersonic flow phenomena in the intake, when compared with wind tunnel data, show satisfactory agreement even though entropy and viscous effects are neglected. M.S.K.

**A85-48993**

### THE CHARACTERISTICS OF UNSTEADY FLOW IN AIR INTAKES [CARACTERISTIQUES DE L'ECOULEMENT INSTATIONNAIRE DANS LES ENTREES D'AIR]

M. BOURIOT, J. DELVILLE, and H. GAREM (Poitiers, Universite, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 22 p. In French. refs
(Contract DRET-83-146)
(AAAF PAPER NT 84-13)

Past and current experimentation to characterize flows in jet engine intakes at the French Center for Aerodynamic and Thermal Studies are reviewed. Experiments on circular and planar intakes have thus far covered the characteristic scales of flow phenomena, wall effects and visualizations, probabilistic velocity and pressure conditions and coherence lengths. Presently, attempts are being made to extend all the previous techniques and measurements, which were in the two-dimensional regime, to three dimensions. The trials are performed in a square-section jet-powered wind tunnel. Instrumentation is available for 18 separate flow measurements spaced 10 deg apart and at five radial locations in the intakes tested. Calibration methods are detailed and initial results for flow velocities in intakes are compared with equivalent data from other wind tunnels. M.S.K.

**A85-48998**

### CALCULATION OF THE FLOW IN AN AIR INTAKE DUCT BY NUMERICAL SOLUTION OF THE EULER EQUATIONS [CALCUL DE L'ECOULEMENT DANS UNE ENTREE D'AIR PAR RESOLUTION NUMERIQUE DES EQUATIONS D'EULER]

CH. KOECK (Matra, S.A., Velizy-Villacoublay, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 25 p. In French. refs
(AAAF PAPER NT 84-24)

Techniques are presented for solving the Euler equations applied to modeling the flow in an intake duct such as found on a turbojet-powered missile. Boundary conditions are defined in terms of wall friction, supersonic upstream flow variables, static pressure downstream, and subsonic velocity and drag forces. A finite volume approach is taken, using multiple grids, to obtain a two-dimensional solution. Account is taken of sideslip and the effects of different angles of attack. The method permits predictions of flow distortions which would cause asymmetrical intake flows. It is noted that a viscous treatment will not necessarily ensure the desired intake conditions. M.S.K.

**A85-49014*** Ohio State Univ., Columbus.
**MODELING TECHNIQUES FOR TRANSONIC AIRFOILS**
S. L. PETRIE, R. J. FREULER, G. M. GREGOREK, and M. B. BRAGG (Ohio State University, Columbus) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 125-143. refs
(Contract NAS1-14406)

In the present comparative study of computer codes for the modeling of two-dimensional, single element airfoil sections for various section geometry classes, two of the codes use vortex singularities methods to obtain the potential flow solution while the remainder solve the full inviscid potential flow equations by means of finite differencing techniques that allow results to be obtained for transonic flow about an airfoil which includes weak shocks. Computational results are presented for a symmetrical airfoil section, a conventional section, and a supercritical one. Icing condition applications of the models are noted. The model codes' range of applicability and agreement with each other and experimental results, as well as their computer run times and memory requirements, are noted. O.C.

**A85-49126#**
**VERIFICATION OF CALCULATION METHODS FOR UNSTEADY AIRLOADS IN THE PREDICTION OF TRANSONIC FLUTTER**
R. J. ZWAAN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 833-839. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart and Rijksluchtvaartdienst. refs
(AIAA PAPER 84-0871)

Various engineering-type methods to calculate unsteady airloads on wings in transonic flow were applied in flutter calculations for a semispan flutter model of a supercritical wing. Verification was performed on the basis of comparing flutter characteristics, in which special attention was given to the prediction of transonic dips in the flutter boundaries. The methods were able to produce useful results when applied complementarily. Author

**A85-49129#**
**GRID GENERATION AND FLOW CALCULATIONS FOR AIRCRAFT GEOMETRIES**
N. P. WEATHERILL and C. R. FORSEY (Aircraft Research Association, Ltd., Bedford, England) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 855-860. Research supported by the Ministry of Defence (Procurement Executive). Previously cited in issue 17, p. 2427, Accession no. A84-38044. refs

**A85-49131*#** Naval Ship Research and Development Center, Bethesda, Md.
**NUMERICAL OPTIMIZATION OF CIRCULATION CONTROL AIRFOIL AT HIGH SUBSONIC SPEED**
T. C. TAI (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and G. H. KIDWELL, JR. (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 869-874. Navy-supported research. Previously cited in issue 21, p. 2988, Accession no. A84-44198. refs

**A85-49133*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FULL POTENTIAL SOLUTIONS OF THREE-DIMENSIONAL SUPERSONIC FLOWS**
K. M. JONES, N. A. TALCOTT, JR. (NASA, Langley Research Center, Hampton, VA), and V. SHANKAR (Rockwell International Science Center, Thousand Oaks, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 881-887. Previously cited in issue 06, p. 705, Accession no. A84-17907. refs

**A85-49138#**
**IS ANY FREE FLIGHT/WIND TUNNEL EQUIVALENCE CONCEPT VALID FOR UNSTEADY VISCOUS FLOW?**
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 915-919. Previously cited in issue 07, p. 845, Accession no. A85-19708. refs

**A85-49141*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**A WIND TUNNEL INLET FLOW SIMULATION**
U. K. KAUL (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 927, 928. Previously cited in issue 07, p. 850, Accession no. A85-20869. refs

**A85-49149**
**FINITE ELEMENT SIMULATION OF TRANSONIC FLOWS BY MODIFIED POTENTIAL AND STREAM FUNCTION METHODS**
W. G. HABASHI (Concordia University, Montreal; Pratt and Whitney Canada, Longueuil, Canada), P. L. KOTIUGA, and L. A. MCLEAN (Pratt and Whitney Canada, Longueuil, Canada) Engineering Analysis (ISSN 0264-682X), vol. 2, Sept. 1985, p. 150-154. refs

This paper presents three alternatives to the classical velocity potential formulation, for inviscid flows with strong shocks. The first method is based on a modified potential, the second on a transonic stream function formulation and the third on a combination that approximates the Euler set of equations. These methods are used to successfully model external flows with strong shocks and choked internal and turbomachinery flows. Author

**A85-49353*** Massachusetts Inst. of Tech., Cambridge.
**UNSTEADY LIFTING-LINE THEORY AS A SINGULAR-PERTURBATION PROBLEM**
A. AHMADI and S. E. WIDNALL (MIT, Cambridge, MA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 153, April 1985, p. 59-81. refs
(Contract NGR-22-009-818)

Unsteady lifting-line theory is developed for a wing of large aspect ratio oscillating at low frequency in inviscid incompressible flow. The wing is assumed to have a rigid chord but a flexible span. Use of the method of matched asymptotic expansions reduces the problem from a singular integral equation to quadrature. The pressure field and airloads, for a prescribed wing shape and motion, are obtained in closed form as expansions in inverse aspect ratio. A rigorous definition of unsteady induced downwash is also obtained. Numerical calculations are presented for an elliptic wing in pitch and heave; compared with numerical lifting-surface theory, computation time is reduced significantly. The present work also identifies and resolves errors in the unsteady lifting line theory of James (1975), and points out a limitation in that of Van Holten (1975, 1976, 1977). Author

**A85-49356**
**COMPUTATION OF INVISCID INCOMPRESSIBLE FLOW WITH ROTATION**
A. RIZZI and L.-E. ERIKSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 153, April 1985, p. 275-312. refs

In numerical studies of incompressible flow fields possessing substantial regions with rotation, difficulties can arise due to the task of having to set up vortex-sheet discontinuities in the field. The alternative is to adopt the Euler equations as the flow model. The recent discovery that a vortex sheet can be generated in the solution of a compressible flow field with separation from the leading edge of a delta wing at high angle of attack has led to the development of numerical methods to solve the compressible Euler equations. However, difficulties arise with respect to the employment of these methods in the case of an incompressible problem. The present investigation has the objective to describe a rather general numerical method which takes the artificial-compressibility approach for solving the steady incompressible Euler equations. G.R.

**A85-49366**

**CHARACTERISTICS OF A TRAILING-EDGE FLOW WITH TURBULENT BOUNDARY-LAYER SEPARATION**

B. E. THOMPSON and J. H. WHITELAW (Imperial College of Science and Technology, London, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 157, Aug. 1985, p. 305-326. SERC-supported research. refs

Experimental techniques, including flying-hot-wire anemometry, have been used to determine the pressure and velocity characteristics of a flow designed to simulate the trailing-edge region of an airfoil at high angle of attack. Emphasis is placed on the region of recirculating flow and on the downstream wake. It is shown that the effect of this recirculation is large even though the details of the flow within it may be unimportant. Normal stresses and cross-stream pressure gradients are important immediately upstream and downstream of the recirculating flow and are associated with strong streamline curvature. The relative importance of the terms in the transport equations for mean momentum and turbulence energy are quantified and the implications for procedures which solve potential-flow and boundary-layer equations and for alternative calculation methods are discussed. Author

**A85-49369**

**A NOTE ON THE STEADY HIGH-REYNOLDS-NUMBER FLOW ABOUT A CIRCULAR CYLINDER**

D. H. PEREGRINE (Bristol, University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 157, Aug. 1985, p. 493-500. refs

The most detailed theoretical description of the steady flow at high Reynolds number about a circular cylinder is given by Smith (1979). It appears to give a satisfactory description of much of the flow field. Numerical solutions for this flow computed by Fornberg (1985) are in conflict with some aspects of Smith's model. An acknowledged weak point in Smith's argument is the lack of a detailed flow for the interior of the eddies, particularly with respect to their rear closure. This paper discusses this aspect of the flow with particular emphasis on the vorticity distribution and with the aid of a solution of the Navier-Stokes equations which is valid at the rear of the eddies. As a result an interpretation of Fornberg's (1980, 1985) results is possible. The self-induced velocity of translation of the vorticity distribution is considered and discussed with reference to the flow as Re approaches infinity. Author

**A85-49652#**

**APPROXIMATE CALCULATION OF FLOW FIELD IN AN INLET WITH ARBITRARY CROSS SECTIONS AND CURVED AXIS**

C. LIN (Northwestern Polytechnical University, Xian, People's Republic of China) (Journal of Applied Mechanics, vol. 1, no. 1, 1984) Northwestern Polytechnical University, English Translation of Selected Papers, ET-12 to ET-17, July 1985, 13 p. Translation.

An approximate solution for steady compressible inviscid potential flow in a slender inlet with a curved axis and arbitrary cross section is obtained using the asymptotic expansions of the flow variables in the framework of the perturbation method. It is shown that the axial velocity component at the centroid of the cross section is equal to the one-dimensional value, while that at a point other than the centroid is inversely proportional to the distance between the point and the center of curvature of the axis. In addition, it is demonstrated that the cross-sectional velocity components can be divided into two parts, with one corresponding to the variation of the cross-section area and the other corresponding to the variation of the cross-section shape. B.J.

**A85-49698**

**ON THE ABRUPT TURBULENT REATTACHMENT DOWNSTREAM OF LEADING-EDGE LAMINAR SEPARATION**

F. T. SMITH (University College, London, England) and J. W. ELLIOTT (Hull, University, England) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 401, no. 1820, Sept. 9, 1985, p. 1-27. SERC-supported research. refs

The unsteady marginal separations in a classical boundary layer are investigated theoretically. The problem of local flow is reduced to the solution of a nonlinear integropartial differential equation for the unknown scaled skin friction which is also proportional to the decrement in the displacement. Numerical solutions for the separations are evaluated analytically, and the results are discussed. It is shown that all short length small disturbances are unstable whenever reversed flow occurs, but for sufficiently confined initial conditions the instabilities accumulate which lead to breakdown after a finite time. In nonlinear breakdown a double structure arises near the point of collapse with an effective 'shock' taking the flow abruptly from the reversed sense just upstream to the forward sense just downstream. The shock forms the link to the sudden transition and turbulent reattachment of laminar eddies at the rounded leading edges. The turbulence effects and the related phenomenon of dynamic stall are also discussed. I.H.

**A85-49702#**

**A SIMPLE AND EFFECTIVE DIFFERENCE SCHEME IN AERODYNAMICS**

D. FU and Y. MA (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 15-23. In Chinese, with abstract in English.

The usual explicit difference schemes in aerodynamics are modified by the addition of a supplementary difference operator. The techniques used in obtaining the new schemes are as simple and easy to manipulate as the original explicit difference schemes but require large time steps for computation in the case of a full implicit scheme. The method is applied to solve 2-D shock wave boundary layer interaction problem. The computed result is compared with experiment and solutions of implicit MacCormack scheme. Numerical experiments show that the developed scheme is effective. Author

**A85-49703#**

**VARIATIONAL PRINCIPLE FAMILIES FOR HYBRID PROBLEMS OF BLADE-TO-BLADE FLOW ALONG AXISYMMETRIC STREAM-SHEET - A UNIFIED VARIABLE-DOMAIN APPROACH**

G. LIU (Shanghai Institute of Mechanical Engineering, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 24-33. In Chinese, with abstract in English. refs

The mathematical tool of functional variations with variable domain is used to develop a new unified theory of various hybrid problems of blade-to-blade flow. Natural boundary conditions and artificial interface are taken into account, as are distributed mass suction and/or injection along the blade surface. A new and sound theoretical basis for FEM and other variational methods, as well as a series of new methods for blade design and modification, are presented. This theory also constitutes an important part of the optimization theory of bladings and can be extended to S2 stream surface flow, fully 3-D flow, and wing design or modification. C.D.

**A85-49705#**

**THE ROLLING VORTEX-DAMPING OF SUPERSONIC WING**

H. YAN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 45-53. In Chinese, with abstract in English. refs

Based on the separated vortex field of the wing and vortex lifetime theory, theoretical formulas for the rolling vortex damping of a supersonic wing due to separated vortex of low aspect ratio sharp-edged wings under roll and angle attack are derived using suppersonic linear theory. Two terms are included in the roll vortex damping, one proportional to the product of attack angle and roll rate, the other proportional to the square of the roll rate. A new theoretical calculation model of roll damping is presented. Values for the rolling damping factor with various combination parameters of the wing planforms are given, and some comparisons between this method and prevalent potential theory are made. C.D.

**A85-49706#**

### RESEARCH ON IMPLICIT APPROXIMATE-FACTORIZATION FINITE-DIFFERENCE METHOD FOR THE EULER EQUATION

F. LIU (Northwestern Polytechnical University, Xian, People's Republic of China), Y. WEI, and T. MAI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 54-62. In Chinese, with abstract in English. refs

An implicit approximate-factorization finite difference method is presented and used to calculate a number of two-dimensional steady flow problems typical in computational fluid dynamics, including (1) subsonic, supersonic, and transonic flows in a straight divergent nozzle, (2) supersonic flows past an infinite wedge and a symmetric double wedge airfoil, and (3) subsonic, transonic, and supersonic flows past the NACA 0012 airfoil. The method treats strong shocks correctly, automatically satisfies the Kutta condition, and permits the use of Courant numbers greater than one so that the computation is accelerated. Both analysis and computation are carried out in body-fitted coordinate systems. The method can be extended to the calculation of three-dimensional problems. C.D.

**A85-49707#**

### A CALCULATING METHOD OF THE BREAKDOWN FEATURE OF THE LEADING-EDGE SEPARATING VORTEX FOR SLENDER DELTA WINGS

B. LIN (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 63-71. In Chinese, with abstract in English. refs

A double layer mode was established, which can be used to describe the separating vortex flow over the delta wing leading-edge. The inner layer of this double layer mode is the vortex core and outer layer is the nonrotational potential flow, both these provide the initial and outer edge conditions which are necessary for solving vortex core development. In the incompressible flow the method not only can compute the initial breakdown angles of attack, but also can compute the breakdown points along the line of the root chord when the angles of attack is more than the critical ones. The theoretical results agree with the experiment measures well and show that the breakdown points are independent of the Reynolds number. Author

**A85-49708#**

### ON ROLLING RESONANCE AND SMALL ASYMMETRICAL AERODYNAMIC FORCE OF RE-ENTRY BODY

J. CAI (China Aerodynamics Research and Development Center, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 72-81. In Chinese, with abstract in English. refs

The rolling resonance of a reentry body is discussed from a flight mechanical and aerodynamical standpoint, and the divergence of the angle of attack of the reentry body is analyzed. It is shown that rolling resonance is a primary hazard for the reentry body. It is suggested that the determination of random ablative configurations and the corresponding mathematical expectations and variances of small asymmetrical aerodynamic coefficients are key problems in the prediction of rolling resonance probability for a reentering body. C.D.

**A85-49710#**

### ANALYTICAL SOLUTIONS FOR UNSTEADY PRANDTL-MEYER FLOW

J. CHEN and J. HUO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 96-101. In Chinese, with abstract in English. refs

Using the frequency perturbation method analytical solutions for unsteady Prandtl Meyer flow are obtained, which consist of a series including up to the fifth power of the frequency. The solutions are held to the expansive surface of a two dimensional supersonic/hypersonic flat wings oscillating harmonically in pitching for the small amplitude and low frequency at arbitrary angle of attack. The contributions of higher power frequency terms of the frequency are analyzed, based on the numerical results in this paper. Author

**A85-49874**

### THE AERODYNAMIC CHARACTERISTICS OF A GU25-5(11)8 AEROFOIL FOR LOW REYNOLDS NUMBERS

R. A. MCD. GALBRAITH (Glasgow, University, Scotland) Experiments in Fluids (ISSN 0723-4864), vol. 3, no. 5, 1985, p. 253-256. refs

Wind tunnel test results are presented for the GU25-5(11)8 airfoil, most commonly used on canard microlights and characterized as a high-lift low-drag airfoil. Data were obtained for the Reynolds number range of 50,000 to 610,000, corresponding to the transition from a laminar separation flow with no reattachment to a fully attached and turbulent flow. Severe performance degradation is reported for the Re (based on freestream velocity and airfoil chord) lower that 300,000. Furthermore, oil flow pattern at the wall/airfoil junction exhibits corner boundary separation before the main airfoil separation bubble, resulting in a strong standing vortex. L.T.

**A85-50104**

### THE ANALYSIS OF COUNTER-ROTATING PROPELLER SYSTEMS

D. J. LESIEUTRE and J. P. SULLIVAN (Purdue University, West Lafayette, IN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 14 p. refs
(SAE PAPER 850869)

A vortex lattice method for the aerodynamic analysis of counter-rotation propellers was developed. This model along with an unsteady Sears analysis for correcting the quasi-steady loadings that are obtained from the vortex lattice model were used to predict the performance of counter-rotation propeller systems. The method developed shows good correlation with experimental results. The investigation into the unsteady loadings on each of the propellers indicates that significant variations in loading occur due to the unsteady flow and due to the propeller blade passage. These variations were found to be as high as 17 percent of the mean value. The parametric studies that were performed indicate that reducing the rear propeller's diameter or rotational speed results in a loss of efficiency. Author

**A85-50105*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### LASER VELOCIMETER MEASUREMENTS OF THE FLOW FIELDS AROUND SINGLE- AND COUNTER-ROTATION PROPELLER MODELS

D. M. DUNHAM, W. L. SELLERS, III (NASA, Langley Research Center, Hampton, VA), and J. W. ELLIOTT (U.S. Army, Structures Laboratory, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 9 p.
(SAE PAPER 850870)

A two-component LV system was used to make detailed measurements of the flow field around both a single-rotation and a counter-rotation propeller/nacelle. The conditions measured for the single-rotation tractor configuration include two different blade angles and two propeller advance ratios, and for the counter-rotation propeller configuration include both pusher and tractor mounts. The measurements show the increasing slipstream velocities and contraction with increasing blade angle and with decreasing advance ratios. Data for the counter-rotation system show that the aft propeller turns the flow in the opposite direction from the front propeller. Additionally, the LV system was used as a diagnostic tool to provide data to explain the large side force measured on the propeller/nacelle at angle-of-attack. Author

**A85-50106*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**NOISE CONSTRAINTS EFFECTING OPTIMAL PROPELLER DESIGNS**

C. J. MILLER (NASA, Lewis Research Center, Cleveland, OH) and J. P. SULLIVAN (Purdue University, West Lafayette, IN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 11 p. Previously announced in STAR as N85-19923. refs
(SAE PAPER 850871)

A preliminary design tool for advanced propellers was developed combining a fast vortex lattice aerodynamic analysis, a fast subsonic point source noise analysis, and an optimization scheme using a conjugate directions method. Twist, chord and sweep distributions are optimized to simultaneously improve both the aerodynamic performance and the noise observed at a fixed relative position. The optimal noise/performance tradeoffs for straight and advanced concept blades are presented. The techniques used include increasing the blade number, blade sweep, reducing the rotational speed, shifting the spanwise loading and diameter changes. E.A.K.

**N85-34114*#** Scientific Research Associates, Inc., Glastonbury, Conn.

**A THREE-DIMENSIONAL VISCOUS FLOW ANALYSIS FOR THE HELICOPTER TIP VORTEX GENERATION PROBLEM Final Report**

S. J. LIN, R. LEVY, S. J. SHAMROTH, and T. R. GOVINDAN Washington NASA Aug. 1985 69 p refs
(Contract NAS1-14904)
(NASA-CR-3906; NAS 1.26:3906) Avail: NTIS HC A04/MF A01 CSCL 01A

The tip vortex flow field occurring in the vicinity of the tip region of a a helicopter rotor blade is a very complicated three-dimensional, viscous flow phenomenon. The details of the flow in the tip region can have a major effect in determining the generated rotor noise and can significantly affect the performance and dynamic loading of the rotor blade. The three-dimensional viscous subsonic tip vortex generation processes is investigated by a numerical procedure which allows spatial forward-marching integration, utilizing flow approximations from the velocity-decomposition approach of Briley and McDonald. The approach has been applied to compute the laminar and turbulent tip vortex flows for a constant thickness slab airfoil with a square tip, a constant thickness slab airfoil with a half round tip and a NACA 0012 airfoil with a half round tip. The basic mechanism of the tip vortex generation process as well as the prediction of vortex appearance, strength and secondary flow shown by the calculations are in qualitative agreement with experimental results. Author

**N85-34115*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AN EVALUATION OF THREE HELICOPTER ROTOR SECTIONS**

R. M. HICKS and L. J. COLLINS (Informatics General Corp., Palo Alto, Calif.) Aug. 1985 122 p refs
(NASA-TM-86719; REPT-85219; NAS 1.15:86719) Avail: NTIS HC A06/MF A01 CSCL 01A

Three helicopter rotor sections were tested in the NASA Ames Research Center 2- by 2-Foot Transonic Wind Tunnel over a Mach range from 0.2 to 0.88. The sections tested had maximum thickness/chord ratios of 0.078, 0.09, and 0.10. The thickest section was of early technology and had been tested previously in other wind tunnels. This section was included in the investigation to establish a basis for comparing the two thinner sections, which were of recent design. The results of the investigation showed that the pitching-moment characteristics for the three airfoil sections were acceptable. The drag divergence Mach numbers for the three sections were 0.80, 0.825, and 0.845 in order of decreasing thickness. Author

**N85-34116*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**USE OF A HYPERBOLIC GRID GENERATION SCHEME IN SIMULATING SUPERSONIC VISCOUS FLOW ABOUT THREE-DIMENSIONAL WINGED CONFIGURATION**

Y. M. RIZK (Informatics General Corp., Palo Alto, Calif.), J. L. STEGER, and D. S. CHAUSSEE Jul. 1985 16 p refs
(NASA-TM-85344; REPT-85344; NAS 1.15:85344) Avail: NTIS HC A02/MF A01 CSCL 01A

The present paper describes a numerical mesh generation technique to be used with an implicit finite difference method for simulating visous supersonic flow about low-aspect-ratio wing body configurations using a single grid strategy. The computational domain is segmented into multiple regions, with borders located in supersonic areas to avoid the otherwise costly interfacing procedure between adjacent segments. The numerical procedure is applied to calculate the turbulent flow around the shuttle orbiter and a canard projectile at supersonic free stream Mach number. Author

**N85-34120#** Glasgow Univ. (Scotland). Dept. of Aeronautics and Fluid Mechanics.

**A DESIGN PROCEDURE TO MODIFY THE TRAILING EDGE UPPER SURFACE PRESSURE GRADIENT OF A GIVEN AEROFOIL**

A. J. NIVEN and R. A. M. GALBRAITH 10 Jul. 1984 29 p refs Sponsored by Westlands Helicopters Public Ltd. Company and UK Science and Engineering Research Council
(GU-AERO-8408) Avail: NTIS HC A03/MF A01

A method whereby the pressure gradient on the trailing edge upper surface of a given airfoil may be modified to enhance or reduce trailing-edge separation during dynamic stall, for a given section, while retaining the leading edge pressure distribution, is outlined. The NACA 23012 airfoil was modified to enhance the boundary layer separation at the trailing-edge. The modification procedure consists of three algorithms: a potential flow panel method allowing calculation of the original pressure gradient at any angle of attack; a procedure allowing the modification of this gradient; and an inverse potential flow panel method to calculate a new profile from the modified vorticity distribution. Author (ESA)

**N85-34121#** Glasgow Univ. (Scotland). Dept. of Aeronautics and Fluid Mechanics.

**THE AERODYNAMIC CHARACTERISTICS OF A GU25-5(11)8 AEROFOIL FOR LOW REYNOLDS NUMBERS**

R. A. M. GALBRAITH 8 Nov. 1984 11 p refs
(GU-AERO-8410) Avail: NTIS HC A02/MF A01

Wind tunnel tests of an airfoil section used for the canards of microlights where low Reynolds numbers are common, over the Reynolds number range 50,000 to 610,000 are summarized. The airfoil exhibits severe degradation of performance below Re = 300,000, a phenomenon known to be quite general. Author (ESA)

**N85-34122#** Glasgow Univ. (Scotland). Dept. of Aeronautics and Fluid Mechanics.

**MODELLING OF UNSTEADY, INCOMPRESSIBLE SEPARATION ON AN AEROFOIL USING AN INVISCID FLOW ALGORITHM**

M. VEZZA and R. A. M. GALBRAITH 8 Nov. 1984 33 p refs
(GU-AERO-8412) Avail: NTIS HC A03/MF A01

A method for the prediction of unsteady, incompressible separated flow over a two dimensional airfoil is presented. The algorithm was developed from an unsteady potential flow model and uses an inviscid formulation for the flow field. The airfoil is represented by vortex panels of linearly varying strength, piecewise continuous at the corners. Discrete vortices with finite cores are used to model the separating shear layers. Unsteady separation modeling, the theoretical framework, and numerical implementation are discussed. Results for flows which tend asymptotically to the steady state are encouraging. Author (ESA)

**N85-34123#** Glasgow Univ. (Scotland). Dept. of Aeronautics and Fluid Mechanics.
**THE COLLECTED DATA FOR RAMP FUNCTION TESTS ON A NACA 23012 AEROFOIL. VOLUME 1: DESCRIPTION AND PRESSURE DATA**
L. Y. SETRO and R. A. M. GALBRAITH 8 Nov. 1984 58 p refs Sponsored by Westlands Helicopters Public Ltd. Company
(Contract MIN-DEF-2048/O26XR/STR)
(GU-AERO-8413-VOL-1) Avail: NTIS HC A04/MF A01

Data for wind tunnel tests in which a NACA 23012 airfoil was subjected to a variety of ramp type displacements in pitch about the quarter chord position are presented. The data clearly illustrate the effect of reduced frequency on airfoil characteristics and the chordal pressure distribution at the midspan position of the airfoil model. Author (ESA)

**N85-34124#** Glasgow Univ. (Scotland). Dept. of Aeronautics and Fluid Mechanics.
**AN INVESTIGATION INTO THE THREE-DIMENSIONAL STALL DEVELOPMENT ON A MODIFIED NACA 23012 AEROFOIL**
A. J. NIVEN and R. A. M. GALBRAITH 22 Nov. 1984 19 p refs Sponsored by United Kingdom Science and Engineering Research Council
(Contract MIN-DEF-2048/026XR/STR)
(GU-AERO-8414) Avail: NTIS HC A02/MF A01

A numerical method of modifying the trailing edge upper surface pressure gradient of a given airfoil was applied to the NACA 23012 airfoil to enhance the trailing edge pressure gradient. The redesigned airfoil was tested in a subsonic wind tunnel. A flow visualization technique, using a fluorescent yellow oil-film, was used to indicate transition regions, laminar separation bubbles, and the positions of turbulent separation. The extent of three-dimensionality, reverse flow, and corner flow separation were also observed. Results show increased boundary layer separation of the modified airfoil, and vindicate the design method. Author (ESA)

**N85-34125#** Glasgow Univ. (Scotland).
**COMMENTS ON THE PREDICTION OF DYNAMIC STALL**
R. A. M. GALBRAITH 20 Mar. 1985 25 p refs
(Contract DAJA45-84-M-0446)
(GU-AERO-8501) Avail: NTIS HC A02/MF A01

Navier-Stokes, discrete vortex, zonal, and empirical methods for predicting dynamic stall were reviewed. It is concluded that accepted test cases by which the performance of dynamic stall methods may be assessed are needed. There is an unresolved dilemma as to which basic prediction philosophy should be adopted. Using the appropriate form of the Navier-Stokes equations in finite difference form requires large and expensive computing power, while the predominantly empirical procedures need little of such power but much expensive data. A summary table provides a quick reference to the methods. Author (ESA)

**N85-34126#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
**AEROELASTIC CONSTRAINTS FOR A WING WEIGHT MINIMIZATION PROCEDURE**
S. G. HEDMAN Feb. 1985 17 p refs
(Contract STU-81-4626)
(FFA-TN-1985-4) Avail: NTIS HC A02/MF A01

Basic formulas of aeroelastic relations for use as constraints in a wing weight optimization procedure are derived. Steady subsonic or supersonic flow is assumed, and a reference plane panel method is chosen as the aerodynamic load generator. Wing elastic deformation is assumed to be a linear function of the applied loads. The effect of changing the amount of wing material for each wing panel on the deformation properties is used in expressions for aeroelastic efficiency and induced drag. The formulas were successfully implemented for a high aspect ratio wing application. Author (ESA)

**N85-34127#** Institut Franco-Allemand de Recherches, St. Louis (France).
**A COMPARISON OF LASER DOPPLER ANEMOMETRY AND PROBE MEASUREMENTS WITHIN THE BOUNDARY LAYER OF AN AIRFOIL AT SUBSONIC FLOW**
P. MEYER, G. KOERBER, H. HOHEISEL (DFVLR, Brunswick), and M. HOEGER (DFVLR, Brunswick) 3 Sep. 1984 18 p refs Presented at 2nd Intern. Symp. on Appl. of Laser Anemometry to Fluid Mech., Lisbon, 2-4 Jul. 1984
(Contract DFVLR-IB-129-84/5)
(ISL-CO-219/84) Avail: NTIS HC A02

Measurements were performed with a Pitot probe and a laser Doppler anemometer in the boundary layer of a NACA 65-213 airfoil with a separation bubble on the suction side. Comparison of the results shows good agreement for attached laminar and turbulent boundary layers, at the separation point, and in the laminar separated region except for reverse flow. Differences between the two techniques are observed only near the reattachment point in flow areas with steep pressure gradients, where the presence of the probe may lead to disturbances in the flow field. The importance of a laminar separation bubble for the improvement of cascade flow and airfoils is discussed. Author (ESA)

**N85-34128#** Institut Franco-Allemand de Recherches, St. Louis (France).
**STUDY OF BOUNDARY LAYER SEPARATION ON A SUPERCRITICAL PROFILE WITH A SPOILER BY MEANS OF A LASER DOPPLER VELOCIMETER**
P. MEYER and G. KOERBER 3 Sep. 1984 8 p refs Presented at 2nd Intern. Symp. on Appl. of Laser Anemometry to Fluid Mech., Lisbon, 2-4 Jul. 1984
(Contract DRET-82-318)
(ISL-CO-225/84) Avail: NTIS HC A02

A supercritical airfoil with a spoiler was studied by a two-dimensional laser Doppler velocimeter. Local and global mean velocity and shear evolutions are presented. Two different separation models can be observed as a function of the spoiler deflection angle: a separated region with one recirculating area (angle of 10 deg) a separated region with areas (angle of 20 and 40 deg). Flow visualizations show a Karman vortex street behind the spoiler. Boundary layer displacement and momentum thickness deduced from the measurements agree with calculations. Author (ESA)

**N85-35156** North Carolina State Univ., Raleigh.
**A STREAM FUNCTION APPROACH TO SOLVING THE CONSERVATIVE EULER EQUATIONS FOR TRANSONIC FLOWS Ph.D. Thesis**
H. L. ATKINS 1984 121 p
Avail: Univ Microfilms Order No. DA8506981

An approach to obtaining steady state solutions to the conservative Euler equations in two dimensions is presented. The approach makes use of the adiabatic assumption, and employs the stream function and the density as dependent variables, thus eliminating one equation and one unknown. The present approach is implemented in two different ways. In the first method, the conservative Euler equations are recast in terms of the density and the stream function to yield a system of two partial differential equations. The resulting equations are stiff, and hence, are solved by a fully implicit method for a geometrically simple internal flow problem. In the second method, the partial differential equation for density is replaced by an algebraic relation. Thus the resulting formulation involves solving one second order partial differential equation for the stream function. The second method is applied to airfoils at transonic speeds. Dissert. Abstr.

**N85-35161*#** National Aeronautics and Space Administration, Washington, D. C.

**PRESENTATION OF THE ACOUSTIC AND AERODYNAMIC RESULTS OF THE ALADIN 2 CONCEPT QUALIFICATION TESTING**

M. COLLARD, C. DOYOTTE, and M. SAGNER Jul. 1985 30 p refs Transl. into ENGLISH of Presentation des Resultats Aerodyn. et Acoust. des Essais de Qualification du Concept Aladin 2, (France), In: AGARD CP-143, Apr. 1974 10 p Original language doc. was announced in IAA as A75-13803 Transl. by Scientific Translation Services, Santa Barbara Calif. Original doc. prep. by Bertin and Cie Company
(Contract NASW-4004)
(NASA-TM-77883; NAS 1.15:77883; CP-143) Avail: NTIS HC A03/MF A01 CSCL 01A

Wind tunnel tests were conducted of a scale model of the Aladin 2 aircraft. The propulsion system configuration is described and the air flow caused by jet ejection is analyzed. Three dimensional flow studies in the vicinity of the engine installation were made. Diagrams of the leading and trailing edge flaps are provided. Graphs are developed to show the aerodynamic performance under conditions of various airspeed and flap deflection. Author

**N85-35162*#** Douglas Aircraft Co., Inc., Long Beach, Calif.

**CALCULATION OF COMPRESSIBLE FLOW ABOUT THREE-DIMENSIONAL INLETS WITH AUXILIARY INLETS, SLATS AND VANES BY MEANS OF A PANEL METHOD Final Contractor Report, 17 Feb. 1983 - 15 Aug. 1985**

J. L. HESS, D. M. FRIEDMAN, and R. W. CLARK Jun. 1985 197 p refs
(Contract NAS3-22250)
(NASA-CR-174975; NAS 1.26:174975; MDC-J3789) Avail: NTIS HC A09/MF A01 CSCL 01A

An efficient and user oriented method was constructed for calculating flow in and about complex inlet configurations. Efficiency is attained by: (1) the use of a panel method; (2) a technique of superposition for obtaining solutions at any inlet operating condition; and (3) employment of an advanced matrix iteration technique for solving large full systems of equations, including the nonlinear equations for the Kutta condition. User concerns are addressed by the provision of several novel graphical output options that yield a more complete comprehension of the flowfield than was possible previously. E.A.K.

**N85-35171#** European Space Agency, Paris (France).

**ESTIMATION OF FLIGHT MECHANICAL VARIABLES BY MEANS OF KALMAN FILTERS**

E. PLAETSCHKE *In its* Lectures of a Flight Mech. Conf. (DFVLR-Mitt-83-05) p 80-92 Jul. 1984 refs Transl. into ENGLISH from "Vortraege eines Flugmechanik-Kolloquiums" rept. DFVLR-Mitt-83-05 DFVLR, Brunswick, Jul. 1983 p 85-99 Original language document was announced as N84-16126
Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne DM 39.20

A data evaluation system was developed to estimate flight-mechanical characteristics. The measurements concern specific aerodynamic forces, angular velocities, and air data (flight velocity, angle of attack, and sliding angle). The measurement data are incompatible due to zero point drift, false calibrations, and noise. The data evaluation system uses the redundancy between the data through the equations or motion to estimate the errors, resulting in a compatible set of data. The state variables are Kalman filter estimated. Author (ESA)

**N85-35173#** Naval Postgraduate School, Monterey, Calif.

**ANALYSIS OF INCOMPRESSIBLE CASCADE FLOWS USING STATE-OF-THE-ART COMPUTER PROGRAMS M.S. Thesis**

P. E. GENSKOW Mar. 1985 65 p
(AD-A155850) Avail: NTIS HC A04/MF A01 CSCL 09B

Two state-of-the-art computer programs, Q3DFLOW and a standard Cebeci boundary layer program as applied to aerodynamic flows in a cascade are examined. Q3DFLOW is a quasi three-dimensional finite element turbomachinery program. Only the incompressible blade-to-blade module of this program is used. The Cebeci boundary layer program is for incompressible, two dimensional, and constant viscosity flows. It is used to calculate boundary layers on a few isolated airfoils and airfoils/blades in a cascade. Experimental data and other analytical computations are compared for both programs. Additionally, the theory and operation of the Cebeci boundary layer program are presented. GRA

**N85-35174#** Naval Postgraduate School, Monterey, Calif.

**THE INFLUENCE OF HELICOPTER TAIL SHAPE ON DRAG: AN AERODYNAMIC STUDY USING A LOW SPEED WIND TUNNEL M.S. Thesis**

C. L. SARGENT Mar. 1985 91 p
(AD-A156304) Avail: NTIS HC A05/MF A01 CSCL 20D

This thesis examines the effect of helicopter tail shape on drag using a low speed wind tunnel at the Naval Postgraduate School. A modification to the Aeronautical Engineering Department's 3.5 ft x 5 ft. wind tunnel was made to update facilities and allow this work. Major R. Scott Mair worked simultaneously to study the effect of nose shape on drag, a result of the 2-man requirement for wind tunnel work. The existing external balance was replaced with an internal balance and a variable angle-of-attack support system was constructed as well. Quantitative data was collected with this balance, and qualitative information was obtained by tufting the models and visualizing the airflow. The equipment built was adequate with the exception of one component of the balance, which will require a new balance to be built. This single deficiency was significant enough to invalidate the output of the balance and as a result any quantitative discussion of how a helicopter's tail shape affects drag. Without this data the explanation of drag using flow visualization is also not practical. GRA

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A85-47259#**

**E AND H FIELDS MEASUREMENTS ON THE TRANSALL C160 AIRCRAFT DURING LIGHTNING FLASHES**

J. P. MOREAU and J. C. ALLIOT (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Lightning and Static Electricity, Paris, France, June 10-12, 1985) ONERA, TP, no. 1985-48, 1985, 8 p. refs
(ONERA, TP NO. 1985-48)

An airborne experiment was carried out to study the microphysical, dynamic, and thermodynamic properties of frontal systems and to determine the main parameters of electrical and electromagnetic phenomena associated with cloud discharges. It is found that a lightning flash lasts several hundred milliseconds and that there are two kinds of flashes, i.e., those beginning with a train of pulses lasting milliseconds and followed by solitary pulses (75 percent of the cases) and those beginning with solitary pulses. Typical E and H field waveforms for the duration of the flashes, recorded with a 2-MHz-bandwidth analog device, are presented, as are E and H waveforms obtained with 100-MHz-bandwidth transient digitizers and electromagnetic transfer functions of a well defined aperture installed on the aircraft fuselage. V.L.

**A85-47684*** Analytical Mechanics Associates, Inc., Mountain View, Calif.

### THE FLIGHT PLANNING - FLIGHT MANAGEMENT CONNECTION

J. A. SORENSEN (Analytical Mechanics Associates, Inc., Mountain View, CA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 174-178. refs

(Contract NAS1-17345)

Airborne flight management systems are currently being implemented to minimize direct operating costs when flying over a fixed route between a given city pair. Inherent in the design of these systems is that the horizontal flight path and wind and temperature models be defined and input into the airborne computer before flight. The wind/temperature model and horizontal path are products of the flight planning process. Flight planning consists of generating 3-D reference trajectories through a forecast wind field subject to certain ATC and transport operator constraints. The interrelationships between flight management and flight planning are reviewed, and the steps taken during the flight planning process are summarized. Author

**A85-48861**

### THE GROWING IMPACT OF GENERAL AVIATION ON THE WORLD'S AVIATION SYSTEM

D. W. FREER (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Bulletin, vol. 40, June 1985, p. 12-16.

Of the world's more than 300,000 total general aviation (GA) aircraft, over three quarters are registered in North America. The growing numbers of GA fixed-wing and rotary-wing aircraft in the past decade, and the forecasts made by the FAA, the Aerospatiale, and Sikorsky Aircraft have disclosed trends towards escalation in growth, as well as towards increasing sophistication of GA aircraft, with growing predominance of the multiengine piston, turboprop, and turbojet fixed-wing and rotary-wing aircraft. The pilots of GA aircraft will have increasingly extensive training and advanced rating. The GA fleet will account for an increasing percentage of total instrument flight operations, international operations, and, in particular, the number of civil helicopters. This growth in GA aircraft operations needs new standards, which are currently being prepared by the ICAO. New and additional international specifications are being drawn for GA, and additional airport facilities for GA aircraft are being developed. An array of statistical data for the period 1977-1995 is included. I.S.

**A85-48862**

### AIRCRAFT ICING MUST NEVER BE UNDERSTIMATED

O. K. TRUNOV (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Grazhdanskogo Vozdushnogo Flota, Moscow, USSR) ICAO Bulletin, vol. 40, June 1985, p. 17-21.

Underrating by the aircraft crew of the hazards of ice formed on the ground is one of the principal factors of ice-related accidents. A study conducted in the framework of Soviet-Swedish technical cooperation revealed quantitative relationships between the extent and geometry of ice covering and the coefficient of lift and the angle of attack, and underscored the necessity of complete ice removal from the aircraft surface before and during takeoff. The most effective current protection in both removing and preventing further accretion of ice is offered by anti- and de-icing fluids. Correct and timely application of anti-icing fluids and mechanical de-icing devices, and continuous supervision of the state of the aircraft up to the moment of take off are discussed, together with the necessary variations in these precautions demanded by different weather and ground conditions. I.S.

**A85-49130*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### POOL FIRE-VENTILATION CROSSFLOW EXPERIMENTS IN A SIMULATED AIRCRAFT CABIN INTERIOR

C. P. BANKSTON and L. H. BACK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 861-868. NASA-supported research. refs

An experimental facility has been built to study pool fire dynamics and flame spread behavior in a 1/3-scale simulated aircraft interior; attention is presently given to pool fire ventilation crossflow using a 'channel' pool fire subjected to crossflow velocities that replicate postcrash conditions in a wide body aircraft. Crossflow velocity is noted to have a strong effect on visible flame geometry, tilting the flame over sharply. A reverse flow ceiling jet of hot gases was also present in all tests, however, and extended far upstream of the fire, so that despite the appearance of the visible flame, the vertical momentum of the plume was strong enough to establish the reverse flow layer and spread smoke and toxic gases upstream against a significant ventilating flow. O.C.

**A85-49140#**

### A NONLINEAR SOLUTION FOR PARACHUTE SUSPENSION LINE DEFORMATION

E. W. ROSS, JR. (U.S. Army, Aeromechanical Engineering Laboratory, Natick, MA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 925, 926. refs

In the present elementary solution for the large, static deformations of a generic suspension line in a solid, flat, circular parachute configuration whose force distribution is similar to that transmitted from the adjacent fabric, the suspension line is idealized as a flexible, initially unstressed and straight string. The family of shapes obtained may be useful as a check on the correctness of the finite element code for the structural part of the calculation. O.C.

**A85-49625**

### ADVANCED ESCAPE SYSTEMS

T. FORD (Martin-Baker /Engineering/, Ltd., Higher Denham, England) Aircraft Engineering (ISSN 0002-2667), vol. 57, Aug. 1985, p. 6-10.

In connection with the introduction of new aircraft, it is often necessary to extend the performance envelope of the escape system. Advances regarding the design and the operation of aviation escape systems are discussed, taking into account developments occurring as a result of work undertaken in response to the U.S. Navy Aircrew Common Ejection Seat (NACES) program. The seat modes of operation of a new escape system include a high-altitude mode, intermediate-altitude modes, and low altitude modes. Attention is given to the mode selector, the Automatic Inflation Modulation (AIM) personnel parachute, the rigid survival kit, the Parachute Deployment Rocket (PDR), an illustration of the high-altitude ejection sequence, and the features of the NACES seat. G.R.

**A85-49907**

### HANDHELD COMPUTER WEIGHT AND BALANCE COMPUTATIONS FOR MILITARY AIRCRAFT

L. J. BRENNER (Horizons Technology, Inc., San Diego, CA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 8 p.

(SAWE PAPER 1582)

An aircraft Weight and Balance Computer (WABC), easy to operate, and allowing considerable flexibility on types of loads and their location, is described. The WABC has two basic modes. In the initial mission planning (Mode I) the user is asked to consider all applicable inputs in terms of weight and moment of the individual tank quantities, cargo, and passengers. Once all the inputs are displayed, the user may adjust his previous inputs (Mode II). This mode will greatly simplify the adjustments by allowing changes in the load in any fuel tank or any compartment without reentering the rest of the original values. After the 'Review All' step, the WABC will step through all the entries required on the Form F,

and, if a printer is available, print the Form F for submission prior to take-off.
I.S.

**N85-34130#** Committee on Public Works and Transportation (U. S. House).
**AVIATION SAFETY (AIRCRAFT PASSENGER SURVIVABILITY AND CABIN SAFETY)**
Washington GPO 1985 780 p refs Hearings before the Subcomm. on Invest. and Oversight of the Comm. on Public Works and Transportation, 98th Congr., 1st Sess., 12-14 Jul. and 1-2 Nov. 1983
(GPO-39-847) Avail: Subcommittee on Investigations and Oversight

Various issues relative to the survival of aircraft passengers are discussed. Aircraft construction materials, firefighting, fireproofing, toxic hazards, fire extinguishers and emergency life sustaining equipment are among the topics discussed. R.J.F.

**N85-35169#** European Space Agency, Paris (France).
**THE CONTRIBUTION MADE BY FLIGHT MECHANICS TO CIVIL AVIATION**
P. HAMEL *In its* Lectures of a Flight Mech. Conf. (DFVLR-Mitt-83-05) p 42-58 Jul. 1984 Transl. into ENGLISH from "Vortraege eines Flugmechanik-Kolloquiums" rept. DFVLR-Mitt-83-05 DFVLR, Brunswick, Jul. 1983 p 47-64 Original language document was announced as N84-16124
Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne DM 39.20

Flight mechanical problems of the pilot-aircraft system due to the introduction of new technologies are discussed. These technologies (e.g., active control technology) are used to reduce fuel costs. Research on an evaluating improving flight characteristics using an Airbus in-flight simulator is discussed.
Author (ESA)

**N85-35175#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
**INVESTIGATION OF EXPERIMENTAL LIGHTWEIGHT FIREWALL MATERIALS FOR A/C ENGINE BAY APPLICATIONS Final Report, 1 Oct. 1983 - 2 May 1984**
J. J. MOYER Wright-Patterson AFB, Ohio AFWAL Apr. 1985 119 p
(AD-A155765; AFWAL-TR-84-2082) Avail: NTIS HC A06/MF A01 CSCL 11G

An evaluation of fire-resistant materials was conducted to identify possible replacements for stainless steel for use as aircraft firewalls. The materials were subjected to the standard firewall (MIL-I-83294), fire-penetration test. In addition, each sample passing this test was further evaluated on weight, thermal protection, and maintenance requirements. An attempt was made to correlate physical properties to fire penetration test performance, but was not successful due to the lack of physical property information. The report identifies those materials which should be developed for use as firewalls and fire-hardening materials on the aircraft.
Author (GRA)

**N85-35176#** Air Command and Staff Coll., Maxwell AFB, Ala.
**INTRODUCTION TO EUROPEAN AIR TRAFFIC CONTROL**
I. J. HAYES Apr. 1985 51 p
(AD-A156328; ACSC-85-1095) Avail: NTIS HC A04/MF A01 CSCL 17G

The Strategic Air Command's authoritative source for instrument flight procedures, SAC Instrument Flight Course (SIFC), has no comprehensive vehicle with which to introduce the European flight environment to crews that may deploy into the unfamiliar airspace. The study acquaints the reader with the overall nature of flying in the European theater and introduces some procedural differences. The study also looks at how the European system is organized, by examining the airspace structure. The study concludes with a look at the military/civilian dichotomy of airspace control in Europe.
GRA

**N85-35177#** Air Command and Staff Coll., Maxwell AFB, Ala.
**INTERNATIONAL FLIGHT PLANNING HANDBOOK**
H. J. GARVIN Apr. 1985 71 p
(AD-A156330; ACSC-85-0915) Avail: NTIS HC A04/MF A01 CSCL 01B

This handbook has been developed to instruct pilots and navigators on basic planning procedures and operations within the international environment. It provides a consolidated source of information to facilitate planning for international flights. The handbook is developed in four chapters covering: (1) an overview of the international environment, followed by checklists with item-by-item amplification of, (2) pre-flight planning, (3) enroute operations, and (4) services and facilities at foreign destinations.
GRA

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A85-47683*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**CONCEPTS AND ALGORITHMS FOR TERMINAL-AREA TRAFFIC MANAGEMENT**
H. ERZBERGER and J. D. CHAPEL (NASA, Ames Research Center, Moffett Field, CA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 166-173. refs

The nation's air-traffic-control system is the subject of an extensive modernization program, including the planned introduction of advanced automation techniques. This paper gives an overview of a concept for automating terminal-area traffic management. Four-dimensional (4D) guidance techniques, which play an essential role in the automated system, are reviewed. One technique, intended for on-board computer implementation, is based on application of optimal control theory. The second technique is a simplified approach to 4D guidance intended for ground computer implementation. It generates advisory messages to help the controller maintain scheduled landing times of aircraft not equipped with on-board 4D guidance systems. An operational system for the second technique, recently evaluated in a simulation, is also described.
Author

**A85-47686*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SIMULATION OF TIME-CONTROL PROCEDURES FOR THE ADVANCED AIR TRAFFIC CONTROL SYSTEM**
L. TOBIAS (NASA, Ames Research Center, Moffett Field, CA) and P. J. OBRIEN (FAA, Technical Center, Atlantic City, NJ) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 185-190. refs

The problem of mixing four-dimensional (4D) equipped aircraft - aircraft equipped with on-board guidance systems that can predict and control the touchdown time of an aircraft to an accuracy of a few seconds throughout the descent - with unequipped aircraft in the terminal area has been investigated via a real-time air traffic control simulation study. The objective of this study was to examine the effect of time errors (at 120 n. mi. from touchdown) on touchdown time scheduling, and to develop efficient algorithms and procedures to null the initial time errors prior to reaching the final control sector (30 n. mi. from touchdown). Results indicate that initial random errors of up to + or - 2 min can be handled via a single speed advisory issued in the arrival control sector, and thus the time schedule is not disrupted.
Author

**A85-47687**
**TIME-CONTROLLED AIRCRAFT GUIDANCE IN UNCERTAIN WINDS AND TEMPERATURES**
J. W. BURROWS and A. CHAKRAVARTY (Boeing Co., Seattle, WA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 191-197. refs

The design requirements on airborne equipment which controls an aircraft so it arrives at an assigned time are mainly driven by the need for satisfactory control during descent. Assuming open-loop control during a typical descent, the final altitude and arrival time errors due to unforecast winds and temperatures aloft are determined. The fuel required for closed-loop control to reduce these errors is given. Equations of motion, suitable for on-board nominal descent trajectory computation using descent area forecasts, are derived, including the effects of winds and temperatures. A sample descent trajectory, obtained by integrating these equations with an actual forecast, is given. The design of descent controllers using feedback of errors relative to the nominal trajectory is treated. The arrival time errors and fuel usage of such controllers for different gain choices and unforecast winds and temperatures are evaluated by simulation. Author

**A85-48175**
**STATUS AND DEVELOPMENT TRENDS OF NAVIGATION SYSTEMS FOR GENERAL AVIATION [STAND AND ENTWICKLUNGSTENDENZEN VON NAVIGATIONSSYSTEMEN FUER DIE ALLGEMEINE LUFTFAHRT]**
K. HURRASS (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) Ortung und Navigation (ISSN 0474-7550), vol. 26, no. 2, 1985, p. 240-251. In German. refs

Technological advances related to the area of electronics have had a decisive effect on the development of navigation systems, taking into account the utilization of integrated components, miroprocessors, and beam deflection tubes. A further growth in the volume of air traffic during the next 12 years is predicted, and safety requirements are expected to become still more demanding. It is therefore necessary to improve further the navigation systems for aviation with respect to navigation accuracy, reliability, and availability. The present paper is concerned with an evaluation of the merits and drawbacks of the currently employed navigation systems, giving attention to developments which will make it possible to meet future demands. The VOR/DME system is considered along with Non Direction Beacons (NDB), inertial navigation, area navigation, Doppler radar, the replacement of the ILS by the TRSB system, GPS, new display systems, and collision avoidance systems. G.R.

**A85-48851**
**THE IMPOSITION OF FLOW CONTROL AVOIDS ATC OVERLOADS**
C. EIGL (International Civil Aviation Organization, Search and Rescue Section, Paris, France) ICAO Bulletin, vol. 40, Feb. 1985, p. 13-16.

The Air Traffic Flow Management (ATFM) unit was organized by the European Air Navigation Planning Group (EANPG) to ensure that an overload of the air traffic control (ATC) in the ATFM Region (which covers all Europe and has a USSR unit) does not occur, and that the traffic flow restrictions are minimized. The most important task of the ATFM is to establish early the anticipated high airspace and landing demand/ATC capacity ratio, and undertake specific action within either the strategic (early planning and coordination) or tactical, short-time measures. In practice, full use of the available ATC capacity is made on a local scale through the allocation of time slots to individual flights, and the adaptation of traffic flow into a given area. A truly regionwide coordination awaits full development of a reliable common data base, the Central Data Bank, which is now in its early phases of operation. This and other activities of the ATFM are planned and coordinated at the periodic EUR meeting of EANPG. I.S.

**A85-48852**
**INITIAL EUROPEAN CENTRAL DATA BANK OF AIR TRAFFIC DEMAND NOW IN OPERATIONAL TRIALS**
B. MARTIN (EUROCONTROL, Brussels, Belgium) ICAO Bulletin, vol. 40, Feb. 1985, p. 17-20.

A Central Data Bank (CDB), established by the Air Traffic Flow Management (ATFM) Planning Group, is to provide the ATFM service in Europe with a common reference data base for a region-wide coordinated demand/capacity assessment among the air traffic control systems of the individual local areas of the member states. The system is serviced by two chains of equipment, each consisting of an IBM 4341 Central Processing Unit attached to an IBM computer used as communications controller. The output, will indicate where and when the traffic demand will reach or exceed specific ATC thresholds. The CDB data are held in the form of Flight Data Records, which provide aircraft identification, and the departure and destination airports. At its present, Phase I, stage, about 80 percent of calculated departures are found to coordinate with the arrivals. I.S.

**A85-49094**
**RECONNOITERING THE ELECTROMAGNETIC SPECTRUM**
M. J. KESSLER Defense Electronics (ISSN 0278-3479), vol. 17, Sept. 1985, p. 107, 108, 110, 112, 114.

New developments in signal intelligence (Sigint) systems are reviewed, with particular attention given to new Sigint aircraft, direction finding, and Elint collection. It is noted that advances in computer science, signal processing, and microcircuitry have led to miniaturization of equipment and increased automation of the airborne EW systems. Higher capability equipment for identifying and locating surface emitters not only permits construction of near real-time electronic order of battle for use in the C3I network but also enables immediate response for the suppression or destruction of perceived threats through the direction of an offensive strike from the Sigint platform. V.L.

**A85-49096**
**INEWS IGNITES TECHNOLOGY TRADE-OFFS AND COMPETITION**
J. B. SCHULTZ Defense Electronics (ISSN 0278-3479), vol. 17, Sept. 1985, p. 136, 137, 139 (3 ff.).

The goals of the phase of demonstration validation for the Integrated Electronic Warfare System (INEWS), the next-generation electronic warfare system for advanced fighter aircraft, are briefly reviewed. The major requirements for the INEWS are examined, and it is noted that the principal technological problem is combining the right mix of VHSIC components and other devices, such as those made of GaAs, into modular architectures that meet all the requirements for weight, space, reliability, and maintainability at a reasonable price. The problem of software is then examined, and goals for the next stages of the project are outlined. V.L.

**A85-49171**
**AUTOMATION IN AIR TRAFFIC MANAGEMENT**
S. RATCLIFFE Journal of Navigation (ISSN 0020-3009), vol. 38, Sept. 1985, p. 405-412. refs

ATC procedures are currently limited by the manpower-intensive nature of the work, the necessity for each ATC to find local solution instead of for the flight as a whole, and the practice of imposing standardized traffic patterns. Automating the critical ATC functions would require reliability at an expected accident potential of 1:1 billion. Computer hardware reliability could be assured with fault tolerant techniques. However, there is no experience base with the needed reliability which would be required of the real-time software required to handle the associated complex situations. Also, humans must be able to oversee the automatic processes. The FAA has announced intentions of automating the cruise flight phase ATC functions with the AERA plan. The system would also, optimally, interface with aircraft on-board flight management computers to enhance flight efficiency. It is concluded that progress toward automation must be pursued cautiously, and at present ATC functions should continue to be in the control of humans aided by computers. M.S.K.

**N85-34131#** Lincoln Lab., Mass. Inst. of Tech., Lexington.

**EFFECT OF INTERFERENCE ON THE PERFORMANCE OF A MINIMUM TCAS 2**

R. G. SANDHOLM 5 Sep. 1985 66 p refs
(Contract DOT-FA77WAI-817; F19628-85-C-0002)
(FAA-PM-84-33; ATC-132) Avail: NTIS HC A04/MF A01

Minimum TCAS 2 equipment is required to operate reliably in all aircraft densities up to the 0.3 transponder-equipped aircraft per square nautical mile anticipated in the Los Angeles Basin in the year 2000. Prototype TCAS equipment has been developed and shown to be capable of providing reliable surveillance in today's highest densities, which reach an average of about 0.1 aircraft per square nmi. Since there are no existing environments that reach the density of asynchronous interference anticipated for the Los Angeles Basin in the year 2000, it is neccessary to generate simulated interference to determine the performance of the TCAS 2 design in that environment. A series of bench tests were conducted for this purpose. Special sources were used to generate asynchronous ATCRBS and Mode S rely signals (fruit) and TACAN DME squitter and interrogation signals Synchronous ATCRBS and Mode S reply sequences were also generated to simulate airborne encounters. The performance was evaluated by observing how the interference signals either degrated the ability of a TCAS 2 unit to receive, process, and track the desired synchronous reply sequences, or caused the TCAS 2 unit to generate false tracks.

Author

**N85-34132#** Aeronautical Research Labs., Melbourne (Australia).

**GUIDELINES FOR THE EVALUATION OF VISUAL APPROACH SLOPE INDICATORS**

J. MILLAR Sep. 1984 34 p refs
(ARL/SYS-R-32; AR-003-962) Avail: NTIS HC A03/MF A01

This report discusses techniques for evaluating the efficacy of Visual Approach Slope Indicators (VASIs) intended for transport aircraft landing at major runways. The discussion is predicated on the assumption that VASI signals should act as a substitute for the information the pilot sees in the natural scene, and a list of design requirements is developed accordingly. Several testing techniques and the utility of information likely to be obtained from each one is outlined. Various aspects of experimental design including the choice of aircraft, pilots, treatments and statistical analysis which can influence the validity of conclusions are highlighted. In many published evaluations to date there has been undue reliance on the subjective opinions of pilots instead of measurements describing flight paths in objective terms. Similarly, operational evaluations have been preferred to more informative experimental tests. Adequate testing of current VASIs could enable substantial improvements to be incorporated into VASI designs of the future, but unfortunately, previous tests have not always been adequate, restricting the pertinence of the findings and limiting the generality of conclusions which might otherwise have influenced subsequent designs.

Author

**N85-35179#** Mitre Corp., McLean, Va.

**FAA REQUIREMENTS FOR MODEL TO SUPPORT CAPACITY, DELAY, NOISE AND ENERGY PROGRAMS**

J. N. BARRER and W. E. WEISS Mar. 1985 63 p
(Contract DTFA01-84-C-00001)
(AD-A155815; MTR-WP-85W00174; FAA-DL5-85-1) Avail: NTIS HC A04/MF A01 CSCL 17G

This paper was written at the request of the FAA Management Steering Group on System Capacity/Airport Capacity in an effort to answer the recurring question, why should the FAA invest resources in the development and maintenance of models? It summarizes the FAA's requirements for modeling capability to analyze the issues of capacity, delay, noise and fuel burn. It concludes that there is a continuing need for such models and an additional need for airspace model(s) to address these issues in a complex terminal environment. The paper includes a detailed summary of those models related to capacity and delay which are currently owned by the FFA.

GRA

**N85-35182#** Air Command and Staff Coll., Maxwell AFB, Ala.

**A GUIDE TO USAF HELICOPTER INSTRUMENT FLIGHT PROCEDURES**

L. O. STENDAHL Apr. 1985 36 p
(AD-A156102; ACSC-85-2610) Avail: NTIS HC A03/MF A01 CSCL 01B

This report presents information concerning USAF helicopter instrument procedures. This guide consolidates existing and new guidance into an up-to-date, single-source document for use by USAF helicopter pilots. If approved by HQ USAF Instrument Flight Center (IFC), portions of this guide will be incorporated into AFM 51-37. The paper first discusses the need for consolidated guidance, unique helicopter characteristics requiring changes to instrument procedures and how airspace design has been adjusted to accommodate helicopter operations. It then outlines procedures for performing basic helicopter instrument flight, and concludes with a chronological approach to helicopter instrument mission planning and accomplishment. Also included are proposed future changes to helicopter airspace design.

GRA

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A85-47256#**

**REVIEW OF AERONAUTICAL FATIGUE INVESTIGATIONS IN FRANCE DURING THE PERIOD 1983-1985**

R. LABOURDETTE (ONERA, Chatillon-sous-Bagneux, France) (International Committee on Aeronautical Fatigue, Symposium, 13th, Pisa, Italy, May 20-24, 1985) ONERA, TP, no. 1985-42, 1985, 22 p.
(ONERA, TP NO. 1985-42)

A brief summary is given of the subject and results of a series of fatigue studies carried out by various aerospace research centers in France during the period 1983-1985. The studies reviewed include the complex fatigue behavior of carbon-epoxy bolted junctions, load monitoring for military aircraft, crack growth lifetime prediction under aeronautical spectrum loading, and analysis and simulation of load spectra for civil aircraft. Other studies discussed include stress intensity factor calculation for built-in or bonded stiffeners, delamination of a composite plate in bending, and flight data acquisition and processing for evaluation of structural fatigue damage.

V.L.

**A85-47302#**

**UNSTEADY AERODYNAMIC FORCES INDUCED BY AEROELASTIC VIBRATIONS OF A TURBOJET ENGINE IN A NACELLE [FORCES AERODYNAMIQUES INSTATIONNAIRES INDUITES PAR LES VIBRATIONS AEROELASTIQUES D'UN REACTEUR EN NACELLE]**

R. DESTUYNDER and J. J. ANGELINI (ONERA, Chatillon-sous-Bagneux, France) (Groupe Sectoriel Franco-Sovietique - Aeronautique, Sous-groupe Aerodynamique, Acoustique Aeronautique et Structures, Reunion, 27th, Chatillon-sous-Bagneux, France, Mar. 11-15, 1985) ONERA, TP, no. 1985-56, 1985, 22 p. In French.
(ONERA, TP NO. 1985-56)

The results of theoretical and experimental studies of the effects of a wing-mounted engine nacelle on unsteady aerodynamic forces are reported. Trials were run in a transonic wind tunnel using a rigidly mounted wing with and without the nacelle. The wing-nacelle aerodynamic interactions were not significant but the aerodynamic pitching oscillations of the nacelle alone were sufficient to induce flapping. A cylindrical lifting surface model for the oscillations of the nacelle is defined and shown to have good agreement with experimental data, as well as with predictions made using a method of doublets. The experimental data are matched if the effects of internal engine rotations are neglected. M.S.K.

**A85-49007**

### STRUCTURAL MODE REAL-TIME SIMULATION

K. J. DYDA and J. SEIGEL (Rockwell International Corp., El Segundo, CA) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 50-59.

Each of the structural modes in real time flight simulation is characterized by a second-order differential equation which is not only coupled structurally with the other modes, but with the aerodynamic six-degrees-of-freedom equations as well. In order to establish the specific structural modes influencing cockpit motion, a process of elimination has been used. Attention is given to the rigid body modes' force equations, the total vehicle's dynamic equations of motion, symmetric and antisymmetric structural mode equations, and cockpit deflections. O.C.

**A85-49008**

### EVALUATION OF THE AFTI/F-16 ON THE LAMARS (LARGE AMPLITUDE MULTI-MODE AEROSPACE RESEARCH SIMULATOR)

T. B. R. SHINN and F. E. UNFRIED (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 60-66.

An advanced fighter, the AFTI/F-16, is being simulated on the Air Force Flight Dynamics Laboratory's LAMARS to evaluate the control system, pilot/control system interface, and the resulting flying qualities. The AFTI/F-16 LAMARS effort was established to provide the Advanced Development Program Office (ADPO) with a means of investigating important program technical issues in the design of the digital flight control system (DFCS) and the automated maneuvering attack system (AMAS). This paper describes the resources available to the Control Synthesis Branch (FIGD) simulation team, decisions made in implementing the overall simulation program, future simulation requirements, some initial results, and future uses for the simulation. Author

**A85-49012**

### SIMULATION'S ROLE IN THE DEVELOPMENT OF THE FUEL EFFICIENT BOEING 757 AND 767 AIRPLANES

C. E. PHILLIPS (Boeing Co., Renton Flight Simulation Center, Seattle, WA) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 107-113.

Over the course of the 757/767 new generation/high fuel efficiency airliners' development, the Renton Flight Simulation Center (RFSC) engineering simulation facility was used in such vital tasks as the establishment of system specifications, the display and evaluation of aircraft handling characteristics, the design, evaluation, and testing of flight management systems, crew workload studies, and the training of pilots. The RFSC's workload grew from 3600 hours of digital simulation in 1977 to 42,000 hours in 1982; over that 5-year period, $22 million were expended in the upgrade and expansion of the RFSC's simulation facilities. O.C.

**A85-49134#**

### THE MCA METHOD OF DETERMINING THRUST OF JET AIRCRAFT IN FLIGHT

R. E. ROSENBERG and G. SCHUCH (Bundesamt fuer Wehrtechnik und Beschaffung, Manching, West Germany) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 888-895. Previously cited in issue 02, p. 131, Accession no. A84-12337.

**A85-49135#**

### PROJECT ADVANTAGE OF AN OBLIQUE WING DESIGN ON A FLEET AIR DEFENSE MISSION

C. D. WILER and S. N. WHITE (Rockwell International Corp., El Segundo, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 896-900. Previously cited in issue 03, p. 10, Accession no. A85-13965 refs

**A85-49136*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### ARRAYS OF BODIES OF REVOLUTION FOR MINIMUM WAVE DRAG

J. N. NIELSEN (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct 1985, p. 901-909. Previously cited in issue 07, p. 854, Accession no. A85-19758. refs

**A85-49173**

### THE EXTENDED RANGE OPERATION OF TWIN-ENGINED PUBLIC TRANSPORT AIRCRAFT. I

V. W. ATTWOOLL (Civil Aviation Authority, London, England) (Royal Institute of Navigation and Royal Aeronautical Society, Meeting, London, England, Feb. 20, 1985) Journal of Navigation (ISSN 0020-3009), vol. 38, Sept. 1985, p. 423-430.

Consideration is given to potential operational and economic constraints on the establishment of suitable North Atlantic flight routes for twin-engine 757, 767 and A 310 transport aircraft. The current ICAO regulations only allow four-engined aircraft on the route, the rules having been defined during an era of lower engine reliability. The regulations also specify 60- and 120-min lower and upper limits on flight time to a suitable airport with two engines or one engine out, respectively. The possible implications of adapting the rule to two-engine aircraft are analyzed in terms of the available alternate landing sites along the route, the distances which would have to be traveled at given possible airspeeds, and the associated penalties (if any) for flying sufficiently safe, rather than most economical, routes. The results indicate that enough alternate landing strips are available to permit taking advantage of the flight economies offered by the new wide-body, two-engined aircraft. M.S.K.

**A85-49174**

### THE EXTENDED RANGE OPERATION OF TWIN-ENGINED PUBLIC TRANSPORT AIRCRAFT. II

A. LISTER (Civil Aviation Authority, London, England) (Royal Institute of Navigation and Royal Aeronautical Society, Meeting, London, England, Feb. 20, 1985) Journal of Navigation (ISSN 0020-3009), vol. 38, Sept. 1985, p. 431-435.

The FAA has, in lieu of a decision by the ICAO, issued an advisory circular listing conditions under which twin-engined transport aircraft such as the A 310, 757 and 767 could operate beyond 60 min flying time from an airport. Reluctance to change the ruling reflects both the previous normal configuration of four engines on transport aircraft and the limited operational experience with large twin-engined aircraft. Certification for operations beyond the 60 min limit will require demonstrable maintenance levels and operational familiarity. All on-board systems must function sufficiently well on one engine, with no intolerable increase in crew workload. Additionally, long-distance flight routes will be allowed only if an adequate number of alternate airports are within reach en route should engine failure occur. The last factor will to a degree be a function of weather forecasts along the planned route. M.S.K.

**A85-49175**

### THE EXTENDED RANGE OPERATION OF TWIN-ENGINED PUBLIC TRANSPORT AIRCRAFT. III

S. GRIEVE (Britannia Airways, Ltd., Luton, England) (Royal Institute of Navigation and Royal Aeronautical Society, Meeting, London, England, Feb. 20, 1985) Journal of Navigation (ISSN 0020-3009), vol. 38, Sept. 1985, p. 435-442; Discussion, p. 442-444.

The U.K. presently permits twin-engine wide-body passenger aircraft to operate on routes 90 min away from alternate airports with both engines on and 60 min with one engine out. Some concern is expressed that the 90 min distance will be eliminated, thus leaving only the 60 min option for long-distance flights. The shorter interval would cripple commercial operation by U.K. carriers in some parts of the world. The limiting rule may be further expanded by tripling the required weather factors, i.e., visibility and ceiling, for acceptable alternate airports. It is noted that the operational record with the engines on the A 310, 757 and 767 aircraft belie any concern over the in-flight failure of both engines. Furthermore, the redundancy and reliability of avionics and hydraulics systems are also sufficent to allay the need for stricter regulations. It is concluded that the new twin-engine aircraft are more reliable than the four-engine predecessors. M.S.K.

**A85-49199**

### FOKKER IMPROVES TRANSPORT DESIGN BASED ON LAUNCH CUSTOMER DEMAND

M. FEAZEL Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Sept. 16, 1985, p. 44, 45, 47.

The upgraded design of the Fokker 100 is described. It was necessary to improve the aircraft in order to meet the airlines' requirements and to create an aircraft that would grow and be useful into the 21st century. The original design of the aircraft, which was basically a derivative of the F-28, is presented. For the new design the same tooling for the fuselage, wing box, and tail were used; however, a new electrical system and auxiliary power unit were developed. The changes in the aerodynamics of the wing are examined, and the components of the all glass Collins Arnic 700 cockpit avionics suite are explained. The seating capacity was not increased, but the maximum takeoff weight was increased to allow for extended ranges. I.F.

**A85-49200**

### FIRST OPERATIONAL MARINE CORPS AV-8B SQUADRON BEGINS SERVICE

B. M. GREELEY, JR. Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Sept. 16, 1985, p. 54, 55, 57, 59, 61.

The utilization and evaluation of the AV-8B Harrier 2 by the U.S. Marine Corps are discussed. The effective attack performance, reliability, and maintainability, and the good handling characteristics of the aircraft are verified by the examples of the aircraft's performance during flight training and operation evaluation. The schedule for the incorporation of the AV-8B into the squadrons and the number of pilots and training required is examined. The features of the aircraft which have simplified the V/STOL training process are described. The changes and added components that were incorporated into the aircraft to increase its reliability are explained. The present combat radius of the AV-8B and the addition of night, under-the-weather capability to the system are described. I.F.

**A85-49579**

### THE EAGLE - A CLASSIC STUDY IN RELIABILITY GROWTH

J. J. HADEL (McDonnell Aircraft Co., St. Louis, MO) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 476-483.

The F-15 Eagle development reliability program is reviewed, emphasizing the product production phase of the aircraft, especially with regard to hardware field problems and corresponding solutions. The effects of cumulative changes in the F-15 are often masked by the combining of data from 'new' and 'old' configurations in Air Force reports. Examples of this masking effect are analyzed to illustrate how misleading the combined data can sometimes be, and the real effects of the changes are examined by segregating the configuration data to reveal the actual extent of reliability growth. Overall reliability growth trends in the Eagle are analyzed which indicate that the reliability of the aircraft has more than tripled in the eight years since initial deployment. The effects of these trends on related parameters such as abort rates and full mission capable rates are shown. C.D.

**A85-49582**

### F-15 READINESS - THE MAINTAINABILITY CONTRIBUTION

C. L. KIRKPATRICK and R. R. OBRIEN (McDonnell Aircraft Co., St. Louis, MO) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 499-504.

The Full Mission Capable (FMC) rate of aircraft maintainability of the F-15 combat aircraft is estimated and compared to classic maintainability indicators. The results are used to predict factors influencing F-15 availability during peacetime and during wartime. Squadron sorties rates of 3.4-4.8 sorties per day per aircraft are predicted based on the Air Force Logistics composite model and historical maintenance rates and repair times. Among the factors influencing the availability of F-15 aircraft during wartime are: the availability of unencumbered dispersed servicing areas; the use of built-in test equipment; and a hot refuel capability with one or two engines running. Maintainability improvements planned for future F-15 designs are briefly reviewed. I.H.

**A85-49656**

### STAR IN THE MAKING

H. HOPKINS Flight International (ISSN 0015-3710), vol. 128, Sept. 7, 1985, p. 23-28.

Astra, which has been built by an Israeli aircraft manufacturer, is the revolutionary product of an evolutionary line of business jets. The aircraft employs an Israeli-developed swept, supercritical wing. Aims of the design of Astra are related to a high-Mach-number cruise (around 0.8), reasonable fuel economy, good long-range performance (at about Mach 0.7), and a high ratio of payload to aircraft weight. Three Astra prototypes have been used in the flight-test program. One aircraft has demonstrated the type's ability to fly coast-to-coast across the United States at Mach 0.8. Observations made during a flight of Astra are discussed, taking into account the start-up, the takeoff, well-balanced handling, cabin considerations, the exemplary stall behavior, and some operational details. G.H.

**A85-49658**

### GIV - GULFSTREAM GOES FURTHER

G. WARWICK Flight International (ISSN 0015-3710), vol. 128, Sept. 14, 1985, p. 28-36.

A new model of the Gulfstream aircraft (G), GIV, is described in detail. The redesigned frame features and the changes in the aircraft systems, engine, and materials, made in the present GIII model, which extend the flight range of GIV to 4300 n.m. at Mach 0.8, and altitudes to 45, 000 ft, and make it more fuel-efficient, are specified. Among the newly added systems, the factory-fitted integrated digital avionics is the most significant. The system includes an automatic flight control system (autopilot and autothrottle), flight management (navigation and performance), electronic displays, including engine instrumentation and crew altering, and sensor integration, all with the dual redundancy as a minimum. The key element in the system is the avionics standard communication bus (ASCB), which transmits and receives information among the subsystems via a two-wire data highway. I.S.

**A85-49672**

**ANALYSIS OF ASYMMETRIC NATURAL VIBRATIONS OF AN AEROPLANE WITH MOVING DEFORMABLE CONTROL SURFACES**

Z. DZYGADLO and J. BLASZCZYK Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 3-4, 1984, p. 393-412. refs

The results of theoretical and numerical studies of natural vibrations of an aircraft with deformable control surfaces are discussed. The deformable assemblies of the aircraft are discretized by introducing beam elements and using the finite element method. The present model is composed of rigid assemblies and deformable assemblies with continuous and jumplike distribution of mass and rigidity. Equations of motion are established for the rigidity. Equations of motion are established for the rigid parts of the fuselage and equations of dynamic equilibrium for the deformable assemblies of the aircraft. A set of equations is obtained whose solution gives the required spectrum of asymmetric vibrations of an aircraft with moving deformable control surfaces. C.D.

**A85-49673**

**ANALYSIS OF NATURAL VIBRATIONS OF A DEFORMABLE AEROPLANE WITH FIXED CONTROL SYSTEMS**

Z. DZYGADLO, I. NOWOTARSKI, and A. OLEJNIK Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 3-4, 1984, p. 413-421. refs

A numerical analysis of the natural frequencies and modes of a deformable aircraft with fixed control surfaces is presented. Results have been obtained for both a fictitious and a real aircraft. The differences between the frequencies and modes of the aircraft having supports of varying rigidities are used to infer that the influence of an elastic support on the natural vibrations can be disregarded if the ratio of the frequency of the support to the lowest natural frequency of the deformable aircraft is small. The model presented here allows the natural frequencies of an aircraft of any geometrical and mass configuration to be studied in an effective way. C.D.

**A85-49912**

**JVX DESIGN TO COST METHODOLOGY**

S. Y. HOWELL (Bell Helicopter Textron, Fort Worth, TX) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 24 p. refs

(SAWE PAPER 1591)

The preliminary design and full scale development phase team that will undertake the design-to-cost (DTC) program for the Joint Services Advanced Vertical Lift Aircraft, designed 'JVX', encompasses employees from such disciplines as engineering cost analysis, finance, industrial engineering, manufacturing engineering, producibility engineering and planning, and procurement. The DTC team uses parametric techniques to predict costs during preliminary design; subsequently, as more detailed information becomes available, the DTC team resorts to 'grass roots' estimating techniques for cost estimation, on the basis of design layouts and detailed design drawings. O.C.

**A85-49915**

**IN-PRODUCTION AIRCRAFT WEIGHT CONTROL**

A. D. G. BAYLY (Lockheed-California Co., Burbank) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 16 p.

(SAWE PAPER 1597)

A development history is presented for weight control efforts directed to successive variants of the maritime patrol/ASW Orion P3 aircraft, which first entered service in 1961. Weight control measures have at various times been prompted by the incorporation of more powerful engines, additional signal analysis equipment, navigation aids, and electronic countermeasures, and rearrangements of internal equipment and stores. Attention is given to major redesign efforts undertaken to reduce weight, and the effect of these efforts on center-of-gravity location. O.C.

**A85-49920**

**AN EVALUATION OF IMPROVED ANALYTICALLY BASED WEIGHT ESTIMATION METHODOLOGIES**

M. K. MYERS (LTV Aerospace and Defense Co., Vaught Aero Products Div., Dallas, TX) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 12 p.

(SAWE PAPER 1616)

A new geometry characterization routine (GCR) was found to be mandatory for updating the existing synthesis programs for modeling changing aircraft configurations in the future. The GCR is primarily a new manner of feeding the configurational data into the Aircraft Synthesis Analysis program (ASAP). It will need a CADAM interface, and routines requiring the spatial coordinates of the aircraft's external and internal envelopes. The interfaces for radar and IR cross-sectional configurations will be useful but are not mandatory. The additional structural mandatory concepts are the blended bodies and buried engines, methods for weight estimates of individual fuselage portions, and alternate wing construction techniques. A new catalogue technique, illustrated with a diagram, will increase the productivity of ASAP. Also discussed are new methods for estimating composite construction, a new approach to structural analysis, and crack growth criteria. I.S.

**A85-49921**

**AFTI MAW - WING OF THE FUTURE**

R. W. RANKIN (Boeing Military Airplane Co., Wichita, KS) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 24 p.

(SAWE PAPER 1617)

The Mission Adaptive Wing (MAW) concept, which is undergoing evaluation in the Advanced Fighter Technology Integrator (AFTI) F-111, draws on recent advancements in materials, actuators and electronic flight control systems to change airfoil profiles in flight, and thereby conform to the diverse requirements of maneuvering, cruise, and low level penetration segments of a mission at either subsonic or supersonic speeds. Variable camber through smooth deformation of leading and trailing edges is achieved by internal actuation/deformation mechanisms and thin wing skin panels. The AFTI F-111 is an ideal test bed in that it is a variable wing sweep aircraft capable of testing variable camber over a wider range of wing geometry conditions. O.C.

**A85-49925**

**A GLANCE AT SOVIET HELICOPTER WEIGHT TRENDS AND A WEIGHT-PREDICTION METHOD**

R. A. SHINN (U.S. Army, Aviation Systems Command, St. Louis, MO) and W. Z. STEPNIEWSKI (International Technical Associates, Ltd., Upper Darby, PA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 21 p. refs

(SAWE PAPER 1627)

The designs of Western and Soviet helicopters in the 5,000-150,000 lb gross-weight range were compared with respect to relative weight empty, zero-range payload, and engine specific weight, as well as relative weights of major helicopter components. The traditional (until the early seventies) Mil and Kamov Soviet helicopters are inferior in their operational productivity to their Western counterparts, mainly because of the weight gap in the airframes and powerplants. However, the operational new-generation and 'hypothetical' helicopters have the weight-empty, and zero-range payload to gross weight ratios similar to those of the Western counterparts. The general approach of a Soviet weight prediction method for major helicopter components, illustrated by weight equations and graphs, is compared to the Western methods, and the use of these methods in structural weight minimization is examined. Aspects of widening the productivity gap between the Soviet and the Western rotary aircraft are discussed. I.S.

**A85-49926**

**COMPUTER AIDED DETERMINATION OF ROTOR BLADE MASS PROPERTIES**

R. HUFF (Hughes Helicopters, Inc., Culver City, CA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 39 p.
(SAWE PAPER 1628)

The present, computer program-implemented method for rotor blade design mass properties analysis allows calculation of individual component characteristics; each structural lamina or geometrical configuration entered is processed by an appropriate subroutine. The results thus obtained are added to totals for subgroup, main group, and case levels. Attention is given to a general procedure for the definition of blade contours at critical points, the classification of blade parts into different categories for analysis, and the properties of spanwise segments selected by the user for calculation and presentation in printouts. O.C.

**A85-49944**

**THE USAF'S CREST PROGRAM**

A. M. HIGGINS and E. O. ROBERTS (USAF, Aerospace Medical Div., Wright-Patterson AFB, OH) SAFE Journal, vol. 15, Fall 1985, p. 10-16. refs

The USAF recently initiated a five-year advanced development (6.3) effort in ejection seat design called CRew EScape Technologies or CREST. The objective of the CREST program is to develop and demonstrate, through full-scale testing, new escape system technologies required to reduce fatalities and major injuries in future aircraft ejections. The CREST design philosophy is based on the concept of adaptive control of the escape system and successful demonstration of the CREST technologies will lay the foundation for the development of the next-generation ejection seat. This paper describes the program's content and schedule with particular emphasis on the current Phase I activities of the CREST contracted effort. In addition, several efforts supporting the CREST program are also discussed. Author

**A85-49945**

**ADAPTIVE OPERATION OF ESCAPE SYSTEMS - A LOOK AT DESIGN REQUIREMENTS**

R. J. DOBBEK (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) SAFE Journal, vol. 15, Fall 1985, p. 22-26. refs

Some design requirements for an escape system which incorporates the adaptive operation technique are presented. This newly designed escape system would generate controlled adaptive performance. The major external parameters that affect the performance of the ejection catapult and must be considered in the design are: (1) variation in ejected mass, (2) variation in propellant temperature, and (3) variation in the surrounding acceleration field acting against the catapult. The design considerations for flight dynamics, which include controlling catapult acceleration and attitude control of the occupied ejection seats, are described. The use of trajectory control to clear the aircraft, to provide a divergent trajectory from other ejectees and equipment, and to prevent premature ground impact is discussed. The development of a recovery system, which is adaptive to changing conditions, is explained. I.F.

**A85-49946**

**GENERALIZED ESCAPE SYSTEM SIMULATION - ITS PURPOSE, RECENT MODIFICATIONS, AND POTENTIAL**

G. E. LIEPINS and S. Y. OHR (Oak Ridge National Laboratory, TN) SAFE Journal, vol. 15, Fall 1985, p. 27-31. Navy-sponsored research.
(Contract DE-AC05-84OR-21400)

The Generalized Escape System Simulation (GESS) code, which is capable of simulating a number of ejection system hardware performances, is discussed. The code is written in FORTRAN, is compatible with most mainframe computers, and contains a number of subroutines. The GESS program can calculate the trajectory for up to four escape system components; examples of how the GESS code models various ejection phenomena are provided. Comparisons of sled test results and analytically computed results with GESS results are graphically presented; GESS results correlated well with escape system test data. Further research is being conducted in order to make the GESS an integral part of an in-service usage data analysis system. A comprehensive flow chart is provided. I.F.

**A85-50101*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CRASHWORTHY DESIGN CONSIDERATIONS FOR GENERAL AVIATION SEATS**

E. ALFARO-BOU, E. L. FASANELLA, and M. S. WILLIAMS (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 16 p. refs
(SAE PAPER 850855)

This report summarizes the experimental research conducted at the NASA Langley Research Center on general aviation seat and occupant crash response and discusses seat design considerations. Included are typical floor acceleration pulses from general aviation airplane crash tests, the performance of typical general aviation seats in a simulated crash environment, and the performance of prototype energy absorbing (EA) seat designs. Static and dynamic seat testing procedures and test facilities are discussed. Also presented are results from a series of dynamic tests of typical general aviation seats and prototype EA seats. Author

**A85-50102*#** National Aeronautics and Space Administration Langley Research Center, Hampton, Va.

**FLIGHT EVALUATION OF AN INSECT CONTAMINATION PROTECTION SYSTEM FOR LAMINAR FLOW WINGS**

C. C. CROOM and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p. refs
(SAE PAPER 850860)

The maintenance of minimum wing leading edge contamination is critical to the preservation of drag-reducing laminar flow; previous methods for the prevention of leading edge contamination by insects have, however, been rendered impractical by their excessive weight, cost, or inconvenience. Attention is presently given to the results of a NASA flight experiment which evaluated the performance of a porous leading edge fluid-discharge ice protection system in the novel role of insect contamination removal; high insect contamination conditions were also noted in the experiment. Very small amounts of the fluid are found to be sufficient for insect contamination protection. O.C.

**A85-50103*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**MANUFACTURING TOLERANCES FOR NATURAL LAMINAR FLOW AIRFRAME SURFACES**

B. J. HOLMES (NASA, Langley Research Center, Hampton, VA), C. J. OBARA, G. L. MARTIN, and C. S. DOMACK (Kentron Internaional, Inc., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 11 p. refs
(SAE PAPER 850863)

Published aircraft surface waviness and boundary layer transition measurements imply that currently achievable low levels of surface waviness are compatible with the natural laminar flow (NLF) requirements of business and commuter aircraft, in the cases of both metallic and composite material airframes. The primary challenge to the manufacture of NLF-compatible surfaces is two-dimensional roughness in the form of steps and gaps at structural joints. Attention is presently given to recent NASA investigations of manufacturing tolerance requirements for NLF surfaces, including flight experiment results. O.C.

**A85-50107**

**PROPULSIVE EFFICIENCY AND AIRCRAFT DRAG DETERMINED FROM STEADY STATE FLIGHT TEST DATA**

G. BULL and G. BENNETT (Mississippi State University, MS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 15 p.
(SAE PAPER 850872)

Propulsive efficiency and aircraft drag are presently derived from steady, level flight speed-power data by a method that is based on a computer formulation of Lock's (1935) equivalent propeller model; this makes the method suitable for use in parameter identification. The results obtained take the form of coefficients of polynomials that define the aircraft and propeller. The method is especially applicable to performance prediction and simulation, because aircraft and propeller are represented by a simple analytical model rather than tables and graphs. O.C.

**A85-50109*** Bolt, Beranek, and Newman, Inc., Canoga Park, Calif.

**FLIGHT INVESTIGATION OF CABIN NOISE CONTROL TREATMENTS FOR A LIGHT TURBOPROP AIRCRAFT**

J. F. WILBY (Bolt Beranek and Newman, Inc., Canoga Park, CA), R. L. ONEAL (Gulfstream Aerospace Corp., Bethany, OK), and J. S. MIXSON (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 16 p. NASA-supported research. refs
(SAE PAPER 850876)

The in-flight evaluation of noise control treatments for a light, twin-engined turboprop aircraft presents several problems associated with data analysis and interpretation. These problems include data repeatability, propeller synchronization, spatial distributions of the exterior pressure field and acoustic treatment, and the presence of flanking paths. They are discussed here with regard to a specific aeroplane configuration. Measurements were made in an untreated cabin and in a cabin fitted with an experimental sidewall treatment. Results are presented in terms of the insertion loss provided by the treatment and comparison made with predictions based on laboratory measurements. Author

**A85-50111*** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**MECHANISMS OF TRANSMISSION AND CONTROL OF LOW-FREQUENCY SOUND IN AIRCRAFT INTERIORS**

C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 14 p. refs
(Contract NAG1-390)
(SAE PAPER 850879)

A simplified analytical model is used to study the principal mechanisms at work in propeller noise source radiation, fuselage response, and the behavior of the coupled inner acoustic field, in order to control low frequency sound in aircraft interiors. Both active and passive methods of noise control are comparatively evaluated in light of the transmission mechanisms. Fuselage vibrational response is noted to be dominated by only a few lower order circumferential modes. O.C.

**A85-50117**

**ADVANCED SYSTEMS FOR THE GULFSTREAM IV**

R. WINTERS (Gulfstream Aerospace Corp., Savannah, GA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 6 p.
(SAE PAPER 850900)

The Gulfstream IV corporate jet aircraft incorporates among its advanced systems solid state electric power generation, digital electronics, and an integrated avionics/subsystems electronic control design. In order to undertake missions with maximum cost effectiveness, least time, or combinations of these two criteria, flight can be automated throughout the takeoff, climb, cruise, descent, and landing regimes, under almost all weather conditions. Attention is given to the cockpit display system, flight management and guidance systems, engine instrument and crew alert systems, steering and braking control, and electrical power generation. O.C.

**A85-50118**

**AIR-CYCLE AIR CONDITIONING OF TURBINE-POWERED GENERAL AVIATION AND COMMUTER AIRCRAFT**

G. K. PAYNE (AiResearch Manufacturing Co., Torrance, CA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 15 p.
(SAE PAPER 850901)

The use of an air cycle system which operates in conjunction with general aviation and commuter aircraft turbine powerplants facilitates the design of systems that can furnish cabin heating, cooling, pressurization, humidity control and temperature control without recourse to an independent power source. Attention is presently given to air cycle system configurations and constituent features; system installation, performance data, and equipment selection guidelines are illustrated. O.C.

**A85-50126**

**USAF DAMAGE TOLERANCE METHODS APPLIED TO GENERAL AVIATION AIRCRAFT DESIGN AND ANALYSIS**

W. A. BARNGROVER (USAF, Logistics Command, Tinker AFB, OK) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p. refs
(SAE PAPER 850915)

Attention is given to potential benefits to be derived from U.S. Air Force expertise and experience in the design and management of damage-tolerant structures, as found in the military standard MIL-STD-1530. The primary factor in the reduction of structural failures to date has been the awareness instilled in personnel of fatigue processes and their symptoms. Aircraft structural integrity program tasks encompass the use of design information, the use of design analyses and development tests, full scale testing, and the compilation of fleet management data. O.C.

**A85-50127**

**THE STRUCTURAL DYNAMICS OF ELECTRO-IMPULSE DE-ICING ON THE LEAR FAN KEVLAR COMPOSITE LEADING EDGE**

T. PARAMASIVAM and G. W. ZUMWALT (Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 15 p. refs
(SAE PAPER 850917)

Attention is given to results obtained to date in analytical studies and laboratory tests of the electro-impulse deicing method, designated 'EIDI', as applied to a Kevlar-reinforced composite wing leading edge under the direction of NASA-Lewis. EIDI uses copper coils inside the leading edge to discharge capacitors and thereby create a rapidly rising and falling electromagnetic field. The repulsive force generated in a fraction of a millisec within the leading edge skin serves to debond and expel attached ice. O.C.

**A85-50129**

**FLIGHT TESTING A LIQUID ICE PROTECTION SYSTEM ON A SINGLE-ENGINE AIRPLANE**

R. L. NEWMAN (Crew Systems Consultants, Yellow Springs, OH) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p. refs
(SAE PAPER 850923)

The installation and testing of a freezing point fluid depressant ice protection system on a single-engine Cessna 206 is discussed. The system sprays an ethylene glycol solution over the leading edge of the wings, empennage, and lift struts. A slinger ring distributes fluid to the propeller and a glycol spraybar deices the windshield. Aft cg stability tests and forward cg control tests were performed to evaluate the handling qualities of the modified aircraft. The system's installation had no effect on the performance of the aircraft. The technique used to estimate droplet diameter is explained. Samples of some flight testing situations are presented. The results revealed the ice protection system is capable of preventing ice accumulation. I.F.

**A85-50130**

**SPORT AIRCRAFT DESIGN TRENDS - SHAPING THE FUTURE OF GENERAL AVIATION**

S. K. WOOD SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 11 p. refs
(SAE PAPER 850881)

The rapidity with which sport aircraft designers can develop and test novel configutation concepts inexpensively has drawn attention to their efforts as a major source of technological innovation. A historical account is presently given for noteworthy sport aircraft development contributions to aeronautical progress, and such recent, highly innovative designs as the Rutan (1975) Vari-Eze are assessed as sources of enhanced efficiency general aviation aircraft configurations. Future projections are made on the basis of recent design trends. O.C.

**A85-50131**

**CONTOUR ASSESSMENT OF FORMED WING PANELS**

H. R. COOK (AVCO Corp., Avco Aerostructure Div., Nashville, TN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 8 p.
(SAE PAPER 850884)

A procedure which utilizes finite element analysis in the contour assessment of formed wing panels is described. This procedure was designed to test age-formed integrally stiffened aluminum alloy panels with skin thickness ranging from 0.50 to 2.00 inches. The first step in the procedure involves the creation of a finite element model, which reflects the bidirectional stiffness of the panel in conjunction with local deviations from contour, using the MSC/NASTRAN computer program. Then finite element analysis, using converted inspection data, is performed to determine the forces required to close the local gaps to within specified shimming allowances. These results are compared to allowable fit-up forces and from this comparison contour adjustment can be determined. An example of the implementation of this procedure on an integrally stiffened panel segment is given. I.F.

**N85-34135*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**FLIGHT TESTING THE FIXED-WING CONFIGURATION OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT (RSRA)**

G. W. HALL and P. M. MORRIS (Army Aeromechanics Lab.) St. Louis, Mo. Army Aviation Systems Command Jun. 1985 17 p
(NASA-TM-86762; REPT-85283; NAS 1.15:86762; USAAVSCOM-TM-85-A-4) Avail: NTIS HC A02/MF A01 CSCL 01C

The Rotor Systems Research Aircraft (RSRA) is a unique research aircraft designed to flight test advanced helicopter rotor system. Its principal flight test configuration is as a compound helicopter. The fixed wing configuration of the RSRA was primarily considered an energy fly-home mode in the event it became necessary to sever an unstable rotor system in flight. While it had always been planned to flight test the fixed wing configuration, the selection of the RSRA as the flight test bed for the X-wing rotor accelerated this schedule. This paper discusses the build-up to, and the test of, the RSRA fixed wing configuration. It is written primarily from the test pilot's perspective. Author

**N85-34136*#** Hydraulic Research Textron, Irvine, Calif. Systems Engineering Div.

**INTELLIGENT REDUNDANT ACTUATION SYSTEM REQUIREMENTS AND PRELIMINARY SYSTEM DESIGN**

P. DEFEO, L. J. GEIGER, and J. HARRIS Sep. 1985 80 p
(Contract NAS2-12081)
(NASA-CR-177366; NAS 1.26:177366; HR-73600253) Avail: NTIS HC A05/MF A01 CSCL 01C

Several redundant actuation system configurations were designed and demonstrated to satisfy the stringent operational requirements of advanced flight control systems. However, this has been accomplished largely through brute force hardware redundancy, resulting in significantly increased computational requirements on the flight control computers which perform the failure analysis and reconfiguration management. Modern technology now provides powerful, low-cost microprocessors which are effective in performing failure isolation and configuration management at the local actuator level. One such concept, called an Intelligent Redundant Actuation System (IRAS), significantly reduces the flight control computer requirements and performs the local tasks more comprehensively than previously feasible. The requirements and preliminary design of an experimental laboratory system capable of demonstrating the concept and sufficiently flexible to explore a variety of configurations are discussed. R.J.F.

**N85-35183** North Carolina State Univ., Raleigh.

**AN AUTOMATED TECHNIQUE FOR ENCASING SPECIFIC PAYLOADS WITH LOW-DRAG FAIRINGS Ph.D. Thesis**

S. R. FOX 1984 492 p
Avail: Univ. Microfilms Order No. DA8507365

The energy crisis and the recent advances in technology have provided the incentive to develop an automated analytical technique that will design low-speed, low-drag vehicles which encase specific payloads. The present work represents an effort to develop such a technique by the coupling of a flow analysis method, an optimization method, a shape perturbation scheme, and a three-dimensional plotting routine. This technique, which is applicable or easily adaptable to both aerodynamic and submerged hydrodynamic vehicle designs, orchestrates shape modifications to an arbitrary circumscribing body within the constraints stipulated by the specific payload. The evidence to date indicates that with astute modeling the present technique can produce low-drag, cost-effective designs. Dissert. Abstr.

**N85-35184*#** Simula, Inc., Phoenix, Ariz.

**DESIGN AND TESTING OF AN ENERGY-ABSORBING CREWSEAT FOR THE F/FB-111 AIRCRAFT. VOLUME 2: DATA FROM SEAT TESTING Final Report, May 1983 - May 1985**

S. J. SHANE Washington NASA Sep. 1985 337 p 3 Vol.
(Contract NAS1-17387)
(NASA-CR-3917; NAS 1.26:3917; TR-84428-VOL-2) Avail: NTIS HC A15/MF A01 CSCL 01C

The unacceptably high injury rate during the escape sequence (including the ejection and ground impact) of the crew module for F/FB-111 aircraft is reviewed. A program to determine if the injury potential could be reduced by replacing the existing crewseats with energy absorbing crewseats is presented. An energy absorbing test seat is designed using much of the existing seat hardware. An extensive dynamic seat test series, designed to duplicate various crew module ground impact conditions is conducted at a sled test facility. Comparative tests with operational F-111 crewseats are also conducted. After successful dynamic testing of the seat, more testing is conducted with the seats mounted in an F-111 crew module. Both swing tests and vertical drop tests are conducted. The vertical drop tests are used to obtain comparative data between the energy absorbing and operational seats. Volume 1 describes the energy absorbing test seat and testing conducted, and evaluates the data from both test series. Volume 2 presents the data obtained during the seat test series, while Volume 3 presents the data from the crew module test series. Author

**N85-35185*#** SKF Industries, Inc., King of Prussia, Pa.

**PLANETARY-GEAR-SUPPORT BEARING TEST RIG DESIGN Contractor Report, 8 Feb. 1983 - 8 Jan. 1985**

J. W. ROSENLIEB Mar. 1985 81 p
(Contract NAS3-23702)
(NASA-CR-174927; NAS 1.26:174927; AT85T004) Avail: NTIS HC A05/MF A01 CSCL 01C

A test rig was designed to evaluate the performance of a spherical roller bearing with a geared outer ring operating under conditions similar to those of a planet bearing in a helicopter transmission. The configuration is an extension of the widely accepted four-square gearbox arrangement. It provides for testing of two bearings simultaneously with outer ring rotation, misalignment, diametrically opposed loading through the gear teeth, and under race lubrication. Instrumentation permits the measurement of inner and outer ring temperature, bearing drag torque, degree of misalignment, outer ring speed, cage speed, and applied load. Author

**N85-35186*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
**ENERGY MANAGEMENT OF THREE-DIMENSIONAL MINIMUM-TIME INTERCEPT Interim Report**
H. G. VISSER, H. J. KELLEY, and E. M. CLIFF Jul. 1983 121 p refs
(Contract NAG1-203)
(NASA-CR-176174; NAS 1.26:176174) Avail: NTIS HC A06/MF A01 CSCL 01C

A real-time computer algorithm to control and optimize aircraft flight profiles is described and applied to a three-dimensional minimum-time intercept mission. Author

**N85-35187#** Aeronautical Research Labs., Melbourne (Australia).
**FATIGUE LIVES OF SPECIMENS REPRESENTING CRITICAL LOCATIONS IN MIRAGE 3 SPARS UNDER AUSTRALIAN AND SWISS TEST SPECTRA**
J. Y. MANN and G. W. REVILL 1985 68 p refs
(ARL-STRUC-R-415; AR-003-998) Avail: NTIS HC A04/MF A01

Full scale flight by flight fatigue tests on Mirage 3 fighter aircraft wings carried out at the Australian Aeronautical Research Laboratories (ARL) and the Swiss Eidgenossisches Flugzeugwerk (F+W) indicated much greater differences in the flights to failure than were expected. This problem has been investigated by conducting fatigue tests on specimens representing the major failure locations in the test wings - a blind anchor nut hole in the Australian case and an interference fit bolt hole in the Swiss case - under flight by flight loading sequences corresponding to those used in the full scale tests. Constant amplitude fatigue tests were also carried out on the blind hole specimens to provide information for life estimation purposes, and fractographic crack propagation studies were conducted on selected blind hole specimens. The experimentally determined lives of both types of specimen were greater under the Australian than the Swiss stress spectrum. Depending on the stress scaling factor considered the life ratio (Australian/Swiss flights) obtained by grouping together the two stress spectra and the two types of specimens were between 3 and 4.2. For the blind anchor nut hole specimens the predicted fatigue lives were less than those obtained experimentally at high stress scaling factors, but at low stress scaling factors the converse was the case. Author

**N85-35188#** Army Test and Evaluation Command, Aberdeen Proving Ground, Md.
**LABORATORY VIBRATION SCHEDULES Final Report**
11 Mar. 1985 243 p Supersedes TOP-1-2-601
(AD-A155856; ITOP-1-2-601; TOP-1-2-601-REV) Avail: NTIS HC A11/MF A01 CSCL 14B

This ITOP describes two types of vibration tests conducted in the laboratory: first, a mission/field secured cargo test to simulate the transportation of Army material as secured cargo during logistical shipments; and second, an application-induced vibration test to simulate the tactical vibration environment experienced by equipment installed in/on ground vehicles or helicopters. No attempt is made to address the vibration environments for equipment installed in fixed-wing aircraft, missiles, and ships (marine equipment). GRA

**N85-35189#** Naval Postgraduate School, Monterey, Calif.
**THE EFFECTS OF PARAMETER VARIATION ON HELICOPTER PERFORMANCE M.S. Thesis**
C. K. KIM Mar. 1985 65 p
(AD-A156027; AD-E900451) Avail: NTIS HC A04/MF A01 CSCL 21G

Six different cases of helicopter main rotor parameter variation are considered for each of three different forward velocities - hover, sixty knots and one-hundred fifty knots in order to consider the effects of the changes on the total power required for the helicopter. The six cases included variations in rotor radius, rotor chord, solidity disc area, rotational velocity and tip velocity. Although strong positive or negative effects may be observed at some velocities, these trends are generally not the same at all velocities, indicating that trade-offs must be made in the design process in order to optimize the level flight performance. GRA

**N85-35190#** Naval Postgraduate School, Monterey, Calif.
**DEVELOPMENT OF NATOPS (NAVAL AIR TRAINING AND OPERATING PROCEDURE STANDARDIZATION) PERFORMANCE SOFTWARE FOR THE H-46D HELICOPTER M.S. Thesis**
J. M. CARAM Mar. 1985 74 p
(AD-A156089) Avail: NTIS HC A04/MF A01 CSCL 09B

This thesis generates closed-form equations for significant and frequently used Naval Air Training and Operating Procedure Standardization (NATOPS) performance charts for the H-46D and H-46A (with T58-GE-10 engines) helicopters. These equations are developed into interactive software for the Hewlett-Packard HP-41CV hand-held programmable calculator. With this software installed in the calculator the user is able to calculate numerous NATOPS performance parameters (expeditiously, with reduced risk of error) both prior to and in flight. Author (GRA)

**N85-35191#** Air Command and Staff Coll., Maxwell AFB, Ala.
**RAFTS: A T-38 REPLACEMENT FOR THE 21ST CENTURY**
R. C. CHAPMAN, JR. Apr. 1985 35 p
(AD-A156103; ACSC-85-0435) Avail: NTIS HC A03/MF A01 CSCL 01C

The Reconnaissance Attack Fighter Training System (RAFTS) is designed to bridge the performance and systems gap between the T-46A and the Advanced Tactical Fighter (ATF). This training system will replace the T-38 now used in undergraduate pilot training. The study addresses the probable training environment, technology, training requirements, syllabi, and embedded training systems in the late 1990's. The study concludes with a conceptual design of the T-38 aircraft replacement for the 21st century. Author (GRA)

**N85-35192#** Naval Postgraduate School, Monterey, Calif.
**DEVELOPMENT OF NATOPS PERFORMANCE SOFTWARE FOR THE SH-3D AND SH-3H HELICOPTERS M.S. Thesis**
J. T. CURTIS Mar. 1985 107 p
(AD-A156140) Avail: NTIS HC A06/MF A01 CSCL 01B

This thesis generates closed form equations for significant and frequently used Naval Air Training and Operating Procedure Standardization (NATOPS) performance charts for the SH-3D and SH-3H helicopters. These equations are developed into interactive software for the Hewlett-Packard HP-41CV hand-held programmable calculator. With this software installed in the calculator the user is able to calculate numerous NATOPS performance parameters (expeditiously, with reduced risk of error) both prior to and in flight. Author (GRA)

**N85-35193#** Air Command and Staff Coll., Maxwell AFB, Ala.
**NEXT GENERATION GUNSHIP**
W. F. HOLLOWAY Apr. 1985 39 p
(AD-A156361; AD-E900463; ACSC-85-1235) Avail: NTIS HC A03/MF A01 CSCL 01C

Special Operations Forces (SOF) possess requirements for unique air-to-ground attack and reconnaissance capabilities. Conventional air assets do not possess these capabilities. The present SOF air-to-ground attack weapon system, the AC-130 gunship, suffers from inherent tactical and system limitations. The study explores the requirements, the tactical employment concepts, and design considerations for a new gunship. The study concludes that a new gunship must not be a modified conventional airplane, but a dedicated weapon system designed and built for SOF. Author (GRA)

**N85-35544#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.
**TYPICAL AND HISTORICAL ASPECTS OF MOTOR GLIDERS AS METEOROLOGICAL MEASURING AIRCRAFT [TYPISCHES UND GESCHICHTLICHES ZUM MOTORSEGLER ALS METEOROLOGISCHES MESSFLUGZEUG]**
M. E. REINHARDT *In its* Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 15-28 Jan. 1985 refs In GERMAN
Avail: NTIS HC A10/MF A01

The history of motor gliders used for meteorological flight since 1920 is depicted. Motor glider is defined. Historical requirements for gliding aircraft with built-in motor are mentioned. The characteristics of motor gliders, their wing loading, and motor power are shown. The milestones marked by these motor gliders are explained. The expectations for meteorological measurements with motor gliders are outlined. Author (ESA)

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A85-47699**
**A LIKELIHOOD FUNCTION METHOD FOR MULTIPLE AIRCRAFT MANEUVER TRACKING**
A. W. WARREN (Boeing Computer Services Co., Tukwila, WA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 415-422. refs

An algorithm for correlating and tracking high G acceleration targets in a multiple target environment is presented. The maneuver adaptation algorithm is based on hypothesis testing correlation logic and the likelihood function method. The surveillance system environment used to test the proposed tracking method is described. The hypotheses and logic for the maneuver tracking are given. The equations necessary for minimizing the likelihood distance function and the modified Gauss-Newton iterative method necessary for establishing the parameters are presented. The procedure for validating or rejecting the maneuver adaptation method is demonstrated. The application of the maneuver adaptation method to a multitarget tracking simulation is discussed. I.F.

**A85-47757*** Carnegie-Mellon Univ., Pittsburgh, Pa.
**VALIDATION OF FAULT-FREE BEHAVIOR OF A RELIABLE MULTIPROCESSOR SYSTEM - FTMP: A CASE STUDY**
E. CLUNE, Z. SEGALL, and D. SIEWIOREK (Carnegie-Mellon University, Pittsburgh, PA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 1112-1120. refs
(Contract NAG1-190)

A program of experiments has been conducted at NASA-Langley to test the fault-free performance of a Fault-Tolerant Multiprocessor (FTMP) avionics system for next-generation aircraft. Baseline measurements of an operating FTMP system were obtained with respect to the following parameters: instruction execution time, frame size, and the variation of clock ticks. The mechanisms of frame stretching were also investigated. The experimental results are summarized in a table. Areas of interest for future tests are identified, with emphasis given to the implementation of a synthetic workload generation mechanism on FTMP. I.H.

**A85-47760**
**A FAULT AND DAMAGE TOLERANT NETWORK FOR AN ADVANCED TRANSPORT AIRCRAFT**
J. H. LALA, A. RAY, R. HARPER (Charles Stark Draper Laboratory, Inc., Cambridge, MA), and D. B. MULCARE (Lockheed-Georgia Co., Marietta, GA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 1138-1142. refs

The concept of a fault and damage tolerant communications network has been proposed previously for applications requiring high reliability. This concept is now being considered for an Advanced Transport Aircraft to connect sensors, actuators and subsystems to a central computer instead of redundant multiplexed data buses. In this paper, the reliability of such a network has been evaluated for a baseline configuration in which all sensors, actuators and communications subsystems are quadruply redundant. The processing overhead associated with managing the network redundancy, uncovering and identifying faults in the nodes and links of the network, and repairing the network in the presence of faults and damage are also estimated. These estimates are derived from execution times of actual algorithms running on a quad redundant computer that interfaces with the simulated network. Author

**A85-47791**
**THE DESIGN OF A FLUIDIC LOW-AIRSPEED SENSOR**
G. MON (U.S. Army, Harry Diamond Laboratories, Adelphi, MD) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1708-1713. Navy-supported research. refs

A low-airspeed sensor (LASS) for military aircraft has been designed and tested. The design of this sensor is based on the interaction of the airsteam and the supply jet of a laminar proportional amplifier. This sensor consists of a fluidic sensing and output transducer system with the appropriate electronic signal processing and readout. The fluidic system is composed of a sensing amplifier and two pressure controlled oscillators (PCOs). The frequency output signals from the PCOs are monitored by using two inexpensive microphones and then converted to non-modulated output voltages by using two frequency-to-voltage converters. These output voltages are then compared with a difference amplifier. The output is displayed with a digital voltmeter and/or it could feed directly into the flight computer. Preliminary test results indicate that this LASS can detect airspeeds between 0 to 12 m/s. Author

**A85-48072**
**ADVANCED AVIONICS FOR THE NEXT GENERATION MILITARY HELICOPTERS**
C. BENNING, B. BOYD, and B. SKINNER (Texas Instruments, Inc., Defense Systems and Electronics Group, Dallas) Vertiflite (ISSN 0042-4455), vol. 31, Sept.-Oct. 1985, p. 24-27.

A development status and integrability evaluation is conducted for state-of-the-art helicopter avionics that may be used in the U.S. Army's 'LHX' rotorcraft development program, with a view to target acquisition time reduction, improvements in mission reliability, and partial or complete automation of pilot functions. Attention is given to a target acquisition subsystem incorporating a forward looking IR sensor and a daylight TV sensor, both of which are connected via high speed bus to the mission computer. Also used will be integrated navigation, communication and identification avionics, aircraft survivability equipment capable of suppressing enemy radar and IR sensor-controlled weapons, and a very high speed IC-based flight computer. O.C.

**A85-48074**
**SIMPLIFYING THE COCKPIT**
D. A. BITTON (Astronautics Corporation of America, Milwaukee, WI) Vertiflite (ISSN 0042-4455), vol. 31, Sept.-Oct. 1985, p. 45-47.

A development status and performance enhancement evaluation is made of a variety of proprietary advanced helicopter avionics and display system designs. Among these are the horizontal situation indicator and attitude director indicator CRT display, the former encompassing flight director cues, glidescope and localizer data, and turn and slip indicator, by means of which UH-60A Black Hawk helicopter pilots during the Grenada intervention obtained course and distance data. Attention is given to a range of CRT multifunction displays, which, as in the case of the 530MG display system, can facilitate nap-of-the-earth helicopter flight by overlaying vertical and horizontal steering commands, radar altitude, and terrain clearance, over forward looking IR sensor imagery. O.C.

**A85-49003**

**EVALUATION OF THE BENEFITS OF ADVANCED AVIONICS SYSTEM TECHNOLOGIES THROUGH COMPUTER SIMULATION**

R. S. LUCKEW, V. L. DUNCAN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and R. BRODERSON (Battelle Memorial Institute, Columbus, OH) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 13-18.

Attention is given to the approach employed by the U.S. Air Force's Wright Aeronautical Laboratories in the evaluation of advanced terrain-following/terrain-avoidance and threat-and-obstacle-avoidance concepts. This methodology simultaneously treats weather, terrain, and defenses as threats, while generating an optimal aircraft penetration path; this path is then converted into a realizable flight path by the BLUEMAX2 flight path generator, and the path data is fed into an 'attrition module' that calculates the probability of aircraft loss on the basis of the given aircraft and scenario. The entire scheme is noted to be adaptable to the examination of such other problems as those related to stealth, ECM, and combinations of these with terrain and threat avoidance techniques. O.C.

**A85-49091**

**MEETING THE CHALLENGE OF ESM/ECM INTEGRATION**

T. H. GREER (Litton Applied Technology, Systems Development Dept., Sunnyvale, CA) Defense Electronics (ISSN 0278-3479), vol. 17, Sept. 1985, p. 74, 76, 78, 80, 82.

Despite the inherent conflict between the basic functions of an airborne radar warning receiver (RWR) and an active onboard jammer system, there is a functional similarity in that both systems must monitor the electromagnetic environment and obtain emitter parameter data in order to perform their distinctly specialized functions. Examples of potential data flow between RWRs and jammers are presented to demonstrate that it is possible to minimize inherent functional conflicts and enhance individual system performance with a well-considered jammer/RWR interface. V.L.

**A85-49949**

**WILL ADVANCED FIGHTER AVIONICS OPERATE WHEN NEEDED?**

Aerospace Engineering (ISSN 0736-2536), vol. 5, Sept. 1985, p. 28-32.

Performance capabilities and availability of avionics systems for combat aircraft are discussed comparatively taking into account major recent improvements brought about through subsystem integration, information fusion, and hardware improvements. It is noted that the vulnerable and expensive unhardened Avionics Intermediate Shops, highly susceptible to battle damage, can be eliminated by introducing on-aircraft maintenance capability. Such issues as spare parts commonality and complexity and fault tolerance of multiple data processors are also addressed. It is concluded that availability of fighter avionics can be markedly improved by functionally pooling the multiple processing resources throughout the system as common system resources. L.T.

**A85-50119**

**HEAD-UP DISPLAYS FOR GENERAL AVIATION**

W. D. KYLE (Flight Dynamics, Inc., Hillsboro, OR) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p.

(SAE PAPER 850902)

The state-of-the-art head-up display (HUD) designs whose incorporation by general aviation cockpit systems is discussed combine intuitive visual flying with essential instrumentation and continuity of visual and mental attention. The flight path vector HUD is especially useful during the critical transition from instrument to visual flight, or at those times when visual cues are either easily lost or nonexistent. O.C.

**N85-34137#** Aeronautical Research Labs., Melbourne (Australia).

**DETERMINATION OF INSTRUMENT ERRORS BY COMPATIBILITY CHECKING: RESULTS FROM DYNAMIC FLIGHT TEST DATA**

R. A. FEIK Sep. 1984 30 p refs

(ARL/AERO-R-162; AR-003-968) Avail: NTIS HC A03/MF A01

The considerable potential benefits of compatibility checking of aircraft dynamic flight data have in the past not been fully realized when applied to real data. It is suggested in this report that this is partly due to the presence of errors in the real data which are not usually accounted for in computer simulation studies. When factors such as accelerometer offset from center of gravity, measurement time delays and other non-linearities are accounted for, good results can be achieved with moderate quality instrumentation. The effect of these factors on the identified instrument errors are studied in this report and confidence in the results established by a careful comparison with instrument calibrations and expected errors. Other considerations, such as the influence of maneuver shape the inclusion of altitude record, are also discussed, and the conditions for successful application of compatibility checking techniques to flight data are summarized. The importance of understanding the instrumentation system is highlighted. Author

## 07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A85-48073**

**A NEW ERA OF FUEL CONTROLS**

L. WATSON (Chandler Evans, Inc., East Hartford, CT) Vertiflite (ISSN 0042-4455), vol. 31, Sept.-Oct. 1875, p. 38, 39.

The Adaptive Fuel Control unit destined for the T-800 turboshaft Advanced Technology Engine of the LHX helicopter program completed its initial flight evaluation in February, 1985. The units automatic and adaptive features enhanced the test vehicle's handling and reduced pilot workload, in keeping with LHX development goals. Also discussed is the EMC-32 Full Authority Digital Electronic Control system, which provides complete power management on all engine operating regimes, and combines full self-diagnostic capability with a simplified hydromechanical system design to minimize unit removals, reduce maintenance time, and cut engine response time in half. O.C.

**A85-49021*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**A GENERALIZED COMPUTER CODE FOR DEVELOPING DYNAMIC GAS TURBINE ENGINE MODELS (DIGTEM)**
C. J. DANIELE (NASA, Lewis Research Center, Cleveland, OH) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 212-221. Previously announced in STAR as N84-12166. refs

This paper describes DIGTEM (digital turbofan engine model), a computer program that simulates two spool, two stream (turbofan) engines. DIGTEM was developed to support the development of a real time multiprocessor based engine simulator being designed at the Lewis Research Center. The turbofan engine model in DIGTEM contains steady state performance maps for all the components and has control volumes where continuity and energy balances are maintained. Rotor dynamics and duct momentum dynamics are also included. DIGTEM features an implicit integration scheme for integrating stiff systems and trims the model equations to match a prescribed design point by calculating correction coefficients that balance out the dynamic equations. It uses the same coefficients at off design points and iterates to a balanced engine condition. Transients are generated by defining the engine inputs as functions of time in a user written subroutine (TMRSP). Closed loop controls can also be simulated. DIGTEM is generalized in the aerothermodynamic treatment of components. This feature, along with DIGTEM's trimming at a design point, make it a very useful tool for developing a model of a specific turbofan engine. B.W.

**A85-49090**
**ROLLS' TAY ENGINE MEETS SCHEDULE FOR GULFSTREAM 4 FIRST FLIGHT**
S. W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Sept. 23, 1985, p. 103, 105, 107.

The components of the Rolls-Royce Tay engine, which is to be used in the Gulfstream 4 and Fokker 100 aircraft, are discussed. The fan section, which is composed of a 44-inch-diameter fan with 22 wide chord, solid snubberless blades, is described. Low airflow noise generation and increased air intake were achieved by raising the bypass ratio of the engine to 3.1. The design and composition of the three-stage intermediate pressure compressor are discussed. The features of the high-pressure turbine system, the airflow control system, and the combustion system are explained. The maintenance schedule of the Tay engine is described. The differences in the engine design for the two aircraft are presented. I.F.

**A85-50112**
**PROP JET SINGLES HAVE ARRIVED**
J. A. SCHWEIBOLD and M. MOLISH, II (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p.
(SAE PAPER 850882)

The development of turboprop and turboshaft engines for single and multiengine aircraft is discussed. The initial development of small gas turbine engines and their use and the development of the first light turboprop aircraft are described. The current turboprop and turboshaft engines were designed with a compact reserve air flow featuring a modular layout so they could be used in all single and multiengine aircraft. A description of the system development for the engine, which concentrated on detail and practical development, is provided. The modern turboprop engine is compact, lightweight, powerful, simple to operate, easy to maintain, and reliable. It provides an aircraft with improved takeoff and landing performance, high climb and descent profiles, increased airspeed, a reduction in outside noise, and increased load. A low cost turboprop engine, which retains all the high quality characteristics associated with a turboprop engine, is currently being developed. I.F.

**A85-50114**
**SINGLE-ENGINE PROPULSION IMPROVEMENT THROUGH INTERCOOLING**
J. H. WELLS (Cessna Aircraft Co., Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 8 p. refs
(SAE PAPER 850894)

The use of air-to-air intercooling between a small aircraft engine's turbocharger and piston inlets allows operation at higher power with lean air-fuel mixtures, while observing cooling or detonation margin limitations; this represents specific fuel consumption improvements at a given output power. Intercoolers can be selected from available cores, or sized specifically to suit airframe requirements. The critical consideration for intercooler sizing is the critical altitude during maximum power climb. O.C.

**A85-50115**
**PORSCHE AIRCRAFT ENGINE P F M 3200**
H. BOTT and H. DORSCH (Porsche AG, Weissach, West Germany) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 16 p.
(SAE PAPER 850895)

A major automobile manufacturer is developing a family of general aviation aircraft engines for the 200-300 hp market; the first such engine to complete certification is a horizontally opposed six-cylinder design generating 212 hp at takeoff with full exhaust muffling, which employs fuel injection and is cooled by an engine-driven fan. A noteworthy feature of this propulsion system is the pilot's ability to control engine power, speed, and fuel mixture to continually optimized values by means of a single lever. Both AVGAS and MOGAS can be used as fuel. The engine is distinguished by low operating cost, low exterior noise, minimum internal vibration and noise, and ease of control. O.C.

**A85-50120**
**CONVERSION OF SMALL AIRCRAFT TO ALLISON TURBINE POWER**
T. F. PIERCY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 12 p.
(SAE PAPER 850906)

Allison Gas Turbine Division, General Motors Corporation, has produced over 20,000 Model 250 gas turbine engines. While the major use of the engine to date has been the turboshaft version for helicopters, many turboprop applications exist and numerous new applications of the turboprop version are in process in the international market. Based on the positive reception of the turboprop engine, Allison has begun a marketing program for the engine in the domestic fixed-wing aircraft market. A major effort to date is the conversion by Allison of a Beechcraft Bonanza A-36 for use in demonstrations of the marked performance improvements with this new powerplant. Author

**A85-50121**
**GARRETT TPE331-12 ENGINE PROVIDES IMPROVED ALTITUDE PERFORMANCE FOR HIGH-SPEED EXECUTIVE TURBOPROP AIRCRAFT**
H. J. KRASNOW (Garrett Turbine Engine Co., Phoenix, AZ) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 7 p.
(SAE PAPER 850908)

**A85-50122**
**AN ELECTRONIC LIMITER FOR AIRCRAFT ENGINES**
A. BROWN (Bendix-Avalex, Inc., St. Laurent, Canada) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 8 p.
(SAE PAPER 850910)

An Electronic Limiter System (ELS), which provides automatic torque and temperature limiting during the critical phase of flight by controlling the fuel controls governing pressure for an aerobatic turboprop engine, is discussed. The operation of the ELS using its Electronic Limiter Unit (ELU), interface valve, shutoff valve, and engine harness is described. The ELU contains the most advanced software system available; it can perform self tests, recover from simple failures, and recalibrate without using trim-pots. The ELU hardware consists of a digital board, an analog board, and a power board. A control algorithm based on a proportional plus integral control for limiting inputs of torque pressure, interturbine temperature, and propeller speed is explained. The performance tests results have demonstrated that with the ELS it is possible to extend the capabilities of conventional gas turbine fuel controls without using complete electronic systems. I.F.

**A85-50132**

**AERODYNAMICS OF LIQUID-COOLED AIRCRAFT ENGINE INSTALLATIONS**

S. J. MILEY (Texas A&M University, College Station) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 12 p. refs
(SAE PAPER 850896)

A comparative evaluation is conducted of the aerodynamic characteristics of liquid-cooled aircraft engine installations with which experience has been gained, often as early as the Second World War. Attention is given to primary design considerations for inlets, diffusers, and warm air exit ports, with emphasis on air inlet aerodynamics and the characteristics of radiator core designs. Unique 'ring radiator' installations are noted which were originated by Kuchemann and Weber (1946). O.C.

**N85-34138*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**HIGH PRESSURE COMPRESSOR COMPONENT PERFORMANCE REPORT**

S. J. CLINE, W. FESLER, H. S. LIU, R. C. LOVELL, and S. J. SHAFFER Sep. 1983 170 p
(Contract NAS3-20643)
(NASA-CR-168245; NAS 1.26:168245; R82AEB437) Avail: NTIS HC A08/MF A01 CSCL 21E

A compressor optimization study defined a 10 stage configuration with a 22.6:1 pressure ratio, an adiabatic efficiency goal of 86.1%, and a polytropic efficiency of 90.6%; the corrected airflow is 53.5 kg/s. Subsequent component testing included three full scale tests: a six stage rig test, a 10 stage rig test, and another 10 stage rig test completed in the second quarter of 1982. Information from these tests is used to select the configuration for a core engine test and an integrated core/low spool test. The test results will also provide data base for the flight propulsion system. The results of the test series with both aerodynamic and mechanical performance of each compressor build are presented. The second 10 stage compressor adiabatic efficiency was 0.848 at a cruise operating point versus a test goal of 0.846. E.A.K.

**N85-34139#** Toronto Univ. (Ontario). Inst. for Aerospace Studies.

**A MODEL OF HYPERSONIC TWO-DIMENSIONAL OBLIQUE DETONATION WAVE RAMJET**

Y. SHENG and J. P. SISLIAN Jul. 1985 27 p refs
(UTIAS-TN-257; ISSN-0082-5263; AD-B094375) Avail: NTIS HC A03/MF A01

The possibility of using an oblique detonation wave ramjet as a power plant for a hypersonic vehicle is examined. The performance of a model of a two dimensional oblique detonation wave ramjet is analyzed in terms of thrust, lift and fuel consumption. Author

**N85-34140*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**COMPONENT-SPECIFIC MODELING Annual Status Report**

R. L. MCKNIGHT May 1985 162 p refs
(Contract NAS3-23687)
(NASA-CR-174765; NAS 1.26:174765; ASR-1) Avail: NTIS HC A08/MF A01 CSCL 21E

A series of interdisciplinary modeling and analysis techniques that were specialized to address three specific hot section components are presented. These techniques will incorporate data as well as theoretical methods from many diverse areas including cycle and performance analysis, heat transfer analysis, linear and nonlinear stress analysis, and mission analysis. Building on the proven techniques already available in these fields, the new methods developed will be integrated into computer codes to provide an accurate, and unified approach to analyzing combustor burner liners, hollow air cooled turbine blades, and air cooled turbine vanes. For these components, the methods developed will predict temperature, deformation, stress and strain histories throughout a complete flight mission. Author

**N85-34141*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**ENERGY EFFICIENT ENGINE. FAN AND QUARTER-STAGE COMPONENT PERFORMANCE REPORT**

S. J. CLINE, P. H. HALTER, J. T. KUTNEY, JR., and T. J. SULLIVAN Jan. 1983 71 p refs
(Contract NAS3-20643)
(NASA-CR-168070; NAS 1.26:168070; R82AEB408) Avail: NTIS HC A04/MF A01 CSCL 21E

The fan configuration for the general Electric/NASA Energy Efficient Engine was selected following an extensive preliminary design study. The fan has an inlet radius ratio of 0.342 and a specific flowrate of 208.9 Kg/sec/sq. m (42.8 1bm/sec/sq. ft). The design corrected tip speed is 411.5 m/sec (1350 ft/sec) producing a bypass flow total-pressure ratio of 1.65 and a core flow total-pressure ratio of 1.6. The design bypass ratio is 6.8. The aerodynamic design point corresponds to the maximum climb power setting at Mach 0.8 and 10.67 Km (35,000 ft) altitude. The fully-instrumented fan component was tested in the Lynn Large Fan Test Facility in 1981. The overall performance results, reported herein, showed excellent fan performance with the fan meeting all of its component test goals of flow, efficiency and stall margin. Author

**N85-34142#** Rolls-Royce Ltd., Derby (England). Manufacturing Labs.

**PERFORMANCE IMPROVEMENTS FROM SURFACING IN AERO ENGINE COMPONENTS**

J. A. S. GRAHAM 8 Nov. 1984 5 p Presented at Surface Eng. Soc., Coventry, England, 8 Nov. 1984
(PNR-90257) Avail: NTIS HC A02/MF A01

Wear resistance of aircraft engine components is discussed, and abradable linings, thermal barrier coatings, and controlled atmospheric spraying are reviewed. It is shown that application of surface treatments and protectives is a cost effective manufacturing approach to promote performance improvements, i.e., integrity and life. At the forefront of such techniques is the flame or thermal spraying technique. Author (ESA)

**N85-34143#** Rolls-Royce Ltd., Derby (England). Mechanical Technology Div.

**SHROUD SEGMENTS FOR UNSHROUDED BLADE TURBINES**

R. S. ATTWOOD 1 Feb. 1985 13 p
(PNR-90260) Avail: NTIS HC A02/MF A01

The thermal requirements of shroud segments for unshrouded blade turbines were assessed by examining the thermal gradient through various types of section. For sections involving ceramic coatings, coating thickness required is defined and related to the cost in terms of cooling air flow. A limitation associated with the use of a compliant layer, as a result of its relatively low conductivity, is discussed. Transpiration of cooling air through the porous compliant layer is suggested. A method of comparative assessment of engine and rig thermal gradients and cycles was used to define a set of test conditions. Author (ESA)

**N85-35194*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**WINGTIP VORTEX PROPELLER Patent**
J. C. PATTERSON, JR., inventor (to NASA) 6 Aug. 1985 9 p
Filed 2 Feb. 1984 Supersedes N84-20495 (22 - 11, p 1602)
(NASA-CASE-LAR-13019-1; US-PATENT-4,533,101;
US-PATENT-APPL-SN-576308; US-PATENT-CLASS-244-199;
US-PATENT-CLASS-244-55) Avail: US Patent and Trademark Office CSCL 01C

A device which increases the energy efficiency of aircraft wherein a wingtip pusher propeller is positioned aft of the wingtip to rotate in the crossflow of the wingtip vortex is presented. The propeller rotates against the vortex swirl creating additional thrust from and attenuating the wingtip vortex by simultaneously extracting energy from the vortex and converting it to propeller blade induced thrust while injecting its high energy wake into the vortex axial flow to dissipate the vortex. The device increases aircraft fuel efficiency by simultaneously increasing thrust and decreasing vortex induced drag. By attenuating the vortex safety to following aircraft is maximized.

Official Gazette of the U.S. Patent and Trademark Office

**N85-35195*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**FLOW MODIFYING DEVICE Patent**
J. S. KELM (General Electric Co., Cincinnati), E. C. VICKERS (General Electric Co., Cincinnati), J. J. WILLIAMS (General Electric Co., Cincinnati), and J. R. TAYLOR, inventors (to NASA) (General Electric Co., Cincinnati) 13 Aug. 1985 10 p Continuation of abandoned US-Patent-Appl-SN-192677 filed 1 Oct. 1980
(NASA-CASE-LEW-13562-2; US-PATENT-4,534,166;
US-PATENT-APPL-SN-500651; US-PATENT-CLASS-60-39.23;
US-PATENT-CLASS-60-748; US-PATENT-CLASS-239-402.5)
Avail: US Patent and Trademark Office CSCL 21E

A swirler for a gas turbine engine combustor is disclosed for simultaneously controlling combustor flow rate, swirl angle, residence time and fuel-air ratio to provide three regimes of operation. A first regime is provided in which fuel-air ratio is less than stoichiometric, NOx is produced at one level, and combustor flow rate is high. In a second regime, fuel-air ratio is nearly stoichiometric, NOx production is less than that of the first regime, and combustor flow rate is low. In a third regime, used for example at highoff, fuel-air ratio is greater than stoichiometric and the combustor flow rate is less than in either of the other regimes.

Author

**N85-35196** Purdue Univ., Lafayette, Ind.
**OPTIMALLY DESIGNED PROPELLERS CONSTRAINED BY NOISE Ph.D. Thesis**
C. J. MILLER 1984 191 p
Avail: Univ. Microfilms Order No. DA8507731

A design tool is developed that will produce an optimum propeller geometry for a given trade-off between noise and performance. A vortex model is used for the aerodynamics and a subsonic compact source model for the noise analysis. Optimizing the twist, chord and sweep distributions produced blades with favorable tradeoffs between noise and performance. The techniques used for noise reduction include: an inboard loading shift, diameter reduction, rotational speed reduction, increased blade sweep, and blade number increase. The trade-offs for the optimized blades show that, for the straight blade, the most effective noise reduction method is to increase the blade number which both increases efficiency and decreases the blade number which both increases efficiency and decreases the noise. This is followed by blade sweep, which can decrease the noise up to 3 dBA with no efficiency loss, and rotational speed reduction, which reduces noise by 4 dBA per percent in efficiency loss. Results demonstrate that this design tool is not only effective, but useful in the search for more efficient and lower noise propulsion methods.

Dissert. Abstr.

**N85-35197*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
**ENERGY EFFICIENT ENGINE PROGRAM TECHNOLOGY BENEFIT/COST STUDY, VOLUME 1 Executive Summary**
D. E. GRAY and W. B. GARDNER Oct. 1983 19 p 2 Vol.
(Contract NAS3-20646)
(NASA-CR-174766-VOL-1; NAS 1.26:174766-VOL-1;
PWA-5594-258-VOL-1) Avail: NTIS HC A02/MF A01 CSCL 21E

Turbofan engine technologies required for the years 2000 to 2010 were studied, to assess the benefits of those technologies, and to formulate programs for developing the technologies required for that time period. Preliminary technology concepts that might be amenable to future development were ranked. Cycle studies, flowpath definition studies, and mechanical configuration studies were used to identify and establish the feasibility of the technologies that would be required in the 2000 to 2010 time frame. It is shown that a turbofan engine with advancements in aerodynamics, mechanical arrangements, and materials offer significant performance improvements over 1988 technology. The benefits of technologies are assessed using fuel burn and direct operating cost plus interest (DOC+I). The concepts could yield thrust specific fuel consumption benefits of almost 16%, fuel burn benefits of up to 24% and DOC+I benefits up to 14% in a long-range airplane relative to energy efficient engine technology levels. Technology development programs are formulated and recommended to realize those benefits

E.A.K.

**N85-35198*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
**ENERGY EFFICIENT ENGINE PROGRAM TECHNOLOGY BENEFIT/COST STUDY, VOLUME 2**
D. E. GRAY and W. B. GARDNER Oct. 1983 109 p refs 2 Vol.
(Contract NAS3-20646)
(NASA-CR-174766-VOL-2; NAS 1.26:174766-VOL-2;
PWA-5594-251-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 21E

The benefit/cost study to identify turbofan engine technologies required for the years 2000 to 2010, the benefits of those technologies were formulated, and programs for developing the technologies required for that time period were formulated. It is shown that there are still many potential benefits to be realized from the advancement of gas turbine engine technology. Preliminary technology concepts that might be amenable to future development were ranked. Cycle studies, flowpath definition studies, and mechancial configuration studies were used to identify and establish the feasibility of the technologies that would be required in the 2000 to 2010 time frame. It is shown that a turbofan engine with advancements in aerodynamics, mechanical arrangements, and materials offers significant performance improvements over 1988 technology. The benefits of the technologies are assessed using fuel burn and direct operating cost plus interest (DOC+I). E.A.K.

**N85-35199*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
**ENERGY EFFICIENT ENGINE, HIGH PRESSURE TURBINE THERMAL BARRIER COATING. SUPPORT TECHNOLOGY REPORT**
E. C. DUDERSTADT and P. AGARWAL May 1983 128 p refs
(Contract NAS3-20643)
(NASA-CR-168037; NAS 1.26:168037; R82AEB293) Avail: NTIS HC A07/MF A01 CSCL 21E

This report describes the work performed on a thermal barrier coating support technology task of the Energy Efficient Engine Component Development Program. A thermal barrier coating (TBC) system consisting of a Ni-Cr-Al-Y bond cost layer and ZrO2-Y2O3 ceramic layer was selected from eight candidate coating systems on the basis of laboratory tests. The selection was based on coating microstructure, crystallographic phase composition, tensile bond and bend test results, erosion and impact test results, furnace exposure, thermal cycle, and high velocity dynamic oxidation test results. Procedures were developed for applying the selected TBC to CF6-50, high pressure turbine blades and vanes. Coated HPT components were tested in three kinds of tests. Stage 1 blades were tested in a cascade cyclic test rig, Stage 2 blades were component high cycle fatigue tested to qualify thermal barrier coated blades for engine testing, and Stage 2 blades and Stage 1 and 2 vanes were run in factory engine tests. After completion of the 1000 cycle engine test, the TBC on the blades was in excellent condition over all of the platform and airfoil except at the leading edge above midspan on the suction side of the airfoil. The coating damage appeared to be caused by particle impingement; adjacent blades without TBC also showed evidence of particle impingement. B.W.

# 08

# AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A85-47253#**

**ACTIVE CONTROL OF THE BUFFETING RESPONSE ON A LARGE MODERN CIVIL AIRPLANE CONFIGURATION IN WIND TUNNEL**

R. DESTUYNDER (ONERA, Chatillon-sous-Bagneux, France) (International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, Apr. 1-3, 1985) ONERA, TP, no. 1985-26, 1985, 9 p.
(ONERA, TP NO. 1985-26)

A large half wing, aeroelastic model of a civil transport aircraft has been built to study the unsteady aerodynamic response of active flaperons in the S1 ONERA wind tunnel. Then, after analyzing the buffet envelope at large angles of attack in a large range of Mach numbers, it was decided to implement an active control to reduce the dynamic wing response due to the buffeting phenomenon. It was designed as a multicontrol system, operating on the various eigen modes of the wing structure by introduction of unsteady aerodynamic damping forces generated by a flaperon motion. The amount of damping which was achieved in the wind tunnel tests shows that a significant improvement can be expected from this control system, regarding fatigue stresses, passenger and crew comfort and extension of the flight envelope. Author

**A85-47688*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FEEDBACK CONTROL FOR FUEL-OPTIMAL DESCENTS USING SINGULAR PERTURBATION TECHNIQUES**

D. B. PRICE (NASA, Langley Research Center, Hampton, VA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 198-203.

In response to rising fuel costs and reduced profit margins for the airline companies, the optimization of the paths flown by transport aircraft has been considered. It was found that application of optimal control theory to the considered problem can result in savings in fuel, time, and direct operating costs. The best solution to the aircraft trajectory problem is an onboard real-time feedback control law. The present paper presents a technique which shows promise of becoming a part of a complete solution. The application of singular perturbation techniques to the problem is discussed, taking into account the benefits and some problems associated with them. A different technique for handling the descent part of a trajectory is also discussed. G.R.

**A85-47696**

**DESIGN OF OPTIMAL LOW-SENSITIVITY CONTROLLERS WITH PRESPECIFIED EIGENVALUES - APPLICATION TO AIRCRAFT LATERAL MOTION**

N. N. SORIAL (Alexandria, University, Egypt) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 384-386. refs

This paper considers the design of an optimal controller to an aircraft performing a lateral maneuver. The closed-loop system has a prescribed set of eigenvalues. Moreover, the closed-loop system is optimal with respect to quadratic performance index and/or its trajectory sensitivity with respect to small variations in the plant parameters from their nominal values. The predicted responses of the resulting closed-loop system are determined for nominal and perturbed plant parameters. The results show that the closed-loop system preserves the achieved properties even in the presence of small deviations in system parameters. Author

**A85-47697**

**DESIGN OF DECOUPLED LONGITUDINAL FLIGHT CONTROL LAWS UTILIZING EIGENSYSTEM ASSIGNMENT**

K. M. SOBEL and E. Y. SHAPIRO (Lockheed-California Co., Burbank, CA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 403-408. refs

Eigenstructure assignment and command generator tracking are applied to the design of pitch pointing and vertical translation control laws for the AFTI F-16 aircraft. The desired eigenvectors are chosen based upon performance and sensitivity considerations. Feedforward command tracking gains are computed to ensure steady state following to the pilot's command. An interesting feature of the design is that both modes may be implemented using the same feedback gains. Furthermore, the aircraft exhibits a conventional response with acceptable handling qualities when a flaperon failure occurs. Author

**A85-47701**

**DESIGN OF A PITCH ORIENTATION CONTROL SYSTEM FOR AIRCRAFT CONTROL IN STALL REGION**

M. M. KULKARNI and V. N. JOSHI (Indian Institute of Technology, Bombay, India) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 434-439. refs

A pitch orientation control system (POCS) has been developed for T-tail aircraft experiencing control reversal with pitch-up in unstable flight regimes. The design approach was based on the short period transfer function for a system of simplified equations having two degrees of freedom. The transfer function describes the situation in which a pole and a zero appear in the right hand control plane. A system of eight dynamic compensators is included to provide stable control in prestall and poststall conditions. The results of a computer simulation of the proposed scheme showed that stable control can be obtained using only one compensator parameter value for the prestall and poststall regimes, respectively. I.H.

**A85-47702**

**AN ADAPTIVE CONTROL OF AN ELECTRO-HYDRAULIC POSITION CONTROL SYSTEM**

M. M. KULKARNI, D. B. TRIVEDI, and J. CHANDRASEKHAR (Indian Institute of Technology, Bombay, India) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 443-448. refs

In a hydraulic system input/output relation of the control valve is nonlinear and load dependent. An adaptive control would therefore be necessary for large changes in load parameter. The paper considers a position control system. This becomes a third order system under inertia load and with compressibility of oil considered. Load pressure and integration of the load pressure are suggested as additional feedbacks. PRBS is used as the input signal and the cross-correlation technique is used for identification of the impulse response. Performance parameters are defined and then they are brought to their respective model parameters by iteratively adjusting the gains of the additional feedback loops. An 8-bit micoroprocessor based system has been useful for identification and control. The proposal seems practical and can be economically implemented. Author

**A85-47717**
**HOW AUTOPILOT REQUIREMENTS CONSTRAIN THE AERODYNAMIC DESIGN OF HOMING MISSILES**
F. W. NESLINE and M. L. NESLINE (Raytheon Co., Missile Systems Div., Bedford, MA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 716-730. refs

When an aerodynamically controlled missile is used in a homing application, the transfer function of the vehicle becomes part of an overall homing and attitude control feedback loop. Therefore, the missile must be designed so that its aerodynamics meet the constraints required to accomplish homing successfully. For radar homing, these constraints are stringent enough to require an autopilot that controls the aerodynamic transfer function using body instruments and internal feedback loops. Even with an autopilot, there are limits on the aerodynamic moment parameters such as M-alpha and M-delta that must be considered at the very beginning of the missile system design. This paper explores the nature and sources of these limits and presents numerical examples to illustrate what kinds of numbers are required. Author

**A85-47734**
**FURTHER APPLICATION OF OUTPUT PREDICTIVE ALGORITHMIC CONTROL TO TERRAIN FOLLOWING**
M. E. BISE (Lear Siegler, Inc., Astronics Div., Dayton, OH) and J. G. REID (Systems Control Technology, Inc., Dayton, OH) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 937-942. refs

The utilization of Output Predicative Algorithmic Control (OPAC) in precision trajectory control is discussed. The design of OPAC, which is a flexible closed-loop system that performs prediction, desired future reference trajectory, and future control calculations in every cycle, is presented. The TTYLON program which computes aircraft dynamics, is described. The Trajectory Controller/Observer Design Aid System (TCODAS) software that controls the design and analysis of the control system is explained. The TTYLON Program was used to design a linearized math model of the F-111/MAW and multiple input control surfaces which was tested and proved suitable for low altitude flying. Both the 35-degree and 58 degree wing sweep models followed the programmed trajectory exactly. The 35-deg model had less oscillations in outparts, due to more direct lift, which resulted in a smoother ride. I.F.

**A85-47788**
**A FLUIDIC FLIGHT CONTROL SYSTEM DEMONSTRATOR**
R. L. WOODS (Texas, University, Arlington) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1691-1694. refs
(Contract N00019-81-C-0351)

This paper presents the concepts and test results of a single-axis fluidic flight control system demonstrator. This demonstrator has a pilot input handle, a fluidic control circuit with an angular rate sensor for feedback, and a fluidic-input servoactuator. Long fluid transmission lines interconnect the three components as they would be in an aircraft. The hydraulic servoactuator can be driven by inputs from the handle or from the motion of the controller containing the rate sensor and thus illustrates the basic control actions necessary for flight control. The experimental test results presented show that the static gain of the system is correct with a position hysteresis of 1.2 percent and a noise of 1.5 percent peak-to-peak. The bandwidth of the system is 1.5 Hz under the limited conditions of the test. The system has the performance expected of a flightworthy control system. Author

**A85-47789**
**PERFORMANCE EVALUATION OF AN ELECTROFLUIDIC FLIGHT CONTROL ACTUATOR**
D. R. KEYSER (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1695-1700. refs

The feasibility of providing fluidic backup control of a fly-by-wire actuator was demonstrated in the laboratory. The concept is compatible with the Navy's Advanced Flight Control Actuation System and offers a realistic approach for providing control after loss of primary flight control caused by electromagnetic pulse or interference. Laboratory testing demonstrated how fluidics can enhance the survivability of fly-by-wire control systems. The test results also demonstrated that this design will provide satisfactory performance for flight testing in the T-2C Technology Demonstrator aircraft. Author

**A85-47790**
**FLUIDICS - A RELIABLE ALTERNATIVE FOR AIRCRAFT CONTROL**
R. BENOIT (Grumman Aerospace Corp., Bethpage, NY) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1701-1707.

The development of fluidic flight control systems (FCS) for aircraft stabilization is discussed. Since the present Fly-By-Wire (FBW) system is susceptible to electronic interference, a nonelectric backup system is necessary. The fluidic system uses laminates, each performing a specific function, to provide sensing, computing, and controlling for the aircraft. Hydraulic oil from the basic hydraulic system is used for sensing and signal transmission. Particular emphasis is placed on the development of fluidic actuators. Fluidic FCS were compared to mechanical systems and FBW systems and proved to be the lightest, most cost effective, and best stabilizing backup system. I.F.

**A85-49011**
**FORWARD-SWEPT WING CONTROL SYSTEM DEVELOPMENT**
D. WALLER and J. BOUDREAU (Grumman Aerospace Corp., Bethpage, NY) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 92-106.

Attention is given to the X-29 Forward Swept Wing research aircraft's Flight Control System (FCS) Flight Simulation Facility with emphasis on implementation problems encountered that relate to this unique aircraft's specific features and the 'pilot in loop' requirement. The FCS's hardware/software simulator test configuration interfaces the X-29 flight simulator to the aircraft's flight control hardware. Mathematical models incorporated in the simulation system include those for the airframe and human (pilot) factors. Four different, basic strategies are used to determine model assignment: maximum realism, maximum dynamic accuracy, minimum number of interfaces, and minimum amount of software maintenance. O.C.

**A85-49128#**
**THE THEORETICAL MINIMUM INDUCED DRAG OF THREE-SURFACE AIRPLANES IN TRIM**
E. R. KENDALL (Gates Learjet Corp., Wichita, KS) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 847-854. Previously cited in issue 20, p. 2853, Accession no. A84-41337. refs

**A85-49132*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**HANDLING QUALITIES RELATED TO STALL/SPIN ACCIDENTS OF SUPERSONIC FIGHTER AIRCRAFT**
S. B. ANDERSON (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 875-880. Previously cited in issue 20, p. 2855, Accession no. A84-42346. refs

**A85-49139*#** Kansas Univ., Lawrence.
**THEORY OF WING ROCK**
C.-H. HSU and C. E. LAN (Kansas, University, Lawrence) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 920-924. Previously cited in issue 07, p. 857, Accession no. A85-19583. refs
(Contract NAG1-134)

**A85-49172**
**THE DELCO PERFORMANCE MANAGEMENT SYSTEM**
P. MOORE and D. M. PAGE (British Caledonian Airways, Ltd., Crawley, England) Journal of Navigation (ISSN 0020-3009), vol. 38, Sept. 1985, p. 413-422.

Design, use and performance features of the Delco transport aircraft performance management system (PMS) for flight economy during ascent, cruise and descent flight phases are described. PMS controls pitch and thrust and is composed of three LRUs: the control display, computer and the switching units. A soft altitude hold is implemented to maintain steady drag in the face of environmental vagueries and the economy gains from not resetting the power levels. Yielding a 1-3 percent fuel saving, the system is projected to repay its cost in a little over a year. An initial 3 mos training program, including simulator time, is combined with refresher courses to ensure full use of PMS during all flight phases. Test operational applications of PMS revealed the benefits of variable-speed climb. M.S.K.

**A85-50123**
**A FULL-TIME YAW DAMPER FOR THE STARSHIP FLYING SCALE PROTOTYPE**
L. R. JOHNSON (Beech Aircraft Corp., Wichita, KS) and S. S. YANG (Beech Aircraft Corp., Wichita; Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 8 p.
(SAE PAPER 850912)

A flight test yaw damper for Dutch roll damping improvement has been designed for the Starship flying scale prototype. An analytical study was also performed using linear analysis of a wide variety of flight conditions. Flight test results confirmed a noticeable improvement in ride qualities with the yaw damper engaged. An unexpected benefit was improved directional handling qualities during deep-stall testing. Author

**A85-50124*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**SIMULATION STUDY OF AN AUTOMATIC TRIM SYSTEM FOR REDUCING THE CONTROL FORCES ON A LIGHT TWIN AFTER AN ENGINE FAILURE**
E. C. STEWART and P. W. BROWN (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 16 p. refs
(SAE PAPER 850913)

An automatic trim system for reducing the control forces after an engine failure on a light twin has been investigated on the Langley General Aviation Simulator. The system schedules open-loop trim tab deflections as a function of differential propeller slipstream dynamic pressure and freestream dynamic pressure. The system is described and the airplane-system static and dynamic characteristics are documented. Three NASA research pilots evaluated the effectiveness of the system for takeoff and landing maneuvers. A variety of off-nominal system characteristics were studied. The system was judged to be generally beneficial, providing a 2 to 3 point improvement in pilot rating for the tasks used in the evaluations. Author

**A85-50125**
**IMPROVED CAPABILITIES OF THE NEW GENERAL AVIATION DIGITAL AUTOPILOTS**
D. M. SAMPSON (Rockwell International Corp., Cedar Rapids, IA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p.
(SAE PAPER 850914)

Digital autopilots are the final link in the introduction of digital avionics equipment to the general aviation market. Although previous analog autopilot systems generally provide excellent performance, digital systems possess many advantages not possible in general aviation analog autopilot systems. Digital autopilots, now available from various manufacturers, benefit from less weight, less cost, fewer wires, enhanced diagnostic capabilities, and enhanced performance. This paper explores these advantages using the Collins APS-85 as an example of an advanced general aviation digital autopilot. Author

**N85-34144*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**GROUND-BASED AND IN-FLIGHT SIMULATOR STUDIES OF FLIGHT CHARACTERISTICS OF A TWIN-FUSELAGE PASSENGER TRANSPORT AIRPLANE DURING APPROACH AND LANDING**
W. D. GRANTHAM, P. M. SMITH (PRC Kentron, Inc.), W. R. NEELY, JR. (AFSC Liaison Office, Hampton, Va.), P. L. DEAL, and K. R. YENNI Sep. 1985 55 p refs
(NASA-TP-2451; L-15941; NAS 1.60:2451) Avail: NTIS HC A04/MF A01 CSCL 01C

Six-degree-of-freedom ground-based and in-flight simulator studies were conducted to evaluate the low-speed flight characteristics of a twin-fuselage passenger transport airplane and to compare these characteristics with those of a large, single-fuselage (reference) transport configuration similar to the Lockheed C-5A airplane. The primary piloting task was the approach and landing task. The results of this study indicated that the twin-fuselage transport concept had acceptable but unsatisfactory longitudinal and lateral-directional low-speed flight characteristics, and that stability and control augmentation would be required in order to improve the handling qualities. Through the use of rate-command/attitude-hold augmentation in the pitch and roll axes, and the use of several turn coordination features, the handling qualities of the simulated transport were improved appreciably. The in-flight test results showed excellent agreement with those of the six-degree-of-freedom ground-based simulator handling qualities tests. As a result of the in-flight simulation study, a roll-control-induced normal acceleration criterion was developed. The handling qualities of the augmented twin-fuselage passenger transport airplane exhibited an improvement over the handling characteristics of the reference (single-fuselage) transport. B.W.

**N85-35200*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**DUAL TOWLINE SPIN-RECOVERY DEVICE Patent**
W. L. WHITE, inventor (to NASA) 3 Sep. 1985 9 p Filed 15 Sep. 1983 Supersedes N83-34934 (21 - 23, p 3738)
(NASA-CASE-LAR-13076-1; US-PATENT-4,538,778; US-PATENT-APPL-SN-532342; US-PATENT-CLASS-244-75-R; US-PATENT-CLASS-244-139; US-PATENT-CLASS-244-113)
Avail: US Patent and Trademark Office CSCL 01C

A device which corrects aerodynamic spin is described wherein a parachute exerts antispin forces on an aircraft to effect spin recovery. The dual parachute towlines and are each attached to the parachute and are attached to the rear fuselage equidistant to and on opposite sides of the aircraft centerline. As the parachute is deployed during spin, the parachute force acts through only the towing and exerts its force outboard of center on the aircraft. As a result, the parachute exerts not only an antispin torque, but additionally causes the aircraft to roll, creating a gyroscopic antispin rolling moment. The additional antispin rolling moment facilitates spin recovery by permitting a relatively smaller parachute to accomplish spin recovery equivalent to that of a larger parachute attached to the center of the rear fuselage.

Official Gazette of the U.S. Patent and Trademark Office

**N85-35201*#** Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.

**THE INTEGRATED MANUAL AND AUTOMATIC CONTROL OF COMPLEX FLIGHT SYSTEMS Semiannual Status Report, Jan. - Aug. 1985**

D. K. SCHMIDT 17 Sep. 1985 112 p refs
(Contract NAG4-1)
(NASA-CR-176166; NAS 1.26:176166) Avail: NTIS HC A06/MF A01 CSCL 01C

Pilot/vehicle analysis techniques for optimizing aircraft handling qualities are presented. The analysis approach considered is based on the optimal control frequency domain techniques. These techniques stem from an optimal control approach of a Neal-Smith like analysis on aircraft attitude dynamics extended to analyze the flared landing task. Some modifications to the technique are suggested and discussed. An in depth analysis of the effect of the experimental variables, such as prefilter, is conducted to gain further insight into the flared land task for this class of vehicle dynamics.

E.R.

**N85-35202*#** Purdue Univ., Lafayette, Ind.

**ANALYSIS OF FLEXIBLE AIRCRAFT LONGITUDINAL DYNAMICS AND HANDLING QUALITIES. VOLUME 1: ANALYSIS METHODS**

M. R. WASZAK and D. S. SCHMIDT Jun. 1985 111 p refs
(Contract NAG1-254)
(NASA-CR-177943-VOL-1; NAS 1.26:177943-VOL-1) Avail: NTIS HC A06/MF A01 CSCL 01C

As aircraft become larger and lighter due to design requirements for increased payload and improved fuel efficiency, they will also become more flexible. For highly flexible vehicles, the handling qualities may not be accurately predicted by conventional methods. This study applies two analysis methods to a family of flexible aircraft in order to investigate how and when structural (especially dynamic aeroelastic) effects affect the dynamic characteristics of aircraft. The first type of analysis is an open loop model analysis technique. This method considers the effects of modal residue magnitudes on determining vehicle handling qualities. The second method is a pilot in the loop analysis procedure that considers several closed loop system characteristics. Volume 1 consists of the development and application of the two analysis methods described above.

B.W.

**N85-35203*#** Purdue Univ., Lafayette, Ind.

**ANALYSIS OF FLEXIBLE AIRCRAFT LONGITUDINAL DYNAMICS AND HANDLING QUALITIES. VOLUME 2: DATA**

M. R. WASZAK and D. K. SCHMIDT Jun. 1985 243 p
(Contract NAG1-254)
(NASA-CR-177943-VOL-2; NAS 1.26:177943-VOL-2) Avail: NTIS HC A11/MF A01 CSCL 01C

Two analysis methods are applied to a family of flexible aircraft in order to investigate how and when structural (especially dynamic aeroelastic) effects affect the dynamic characteristics of aircraft. The first type of analysis is an open loop modal analysis technique. This method considers the effect of modal residue magnitudes on determining vehicle handling qualities. The second method is a pilot in the loop analysis procedure that considers several closed loop system characteristics. Both analyses indicated that dynamic aeroelastic effects caused a degradation in vehicle tracking performance, based on the evaluation of some simulation results. Volume 2 consists of the presentation of the state variable models of the flexible aircraft configurations used in the analysis applications mode shape plots for the structural modes, numerical results from the modal analysis frequency response plots from the pilot in the loop analysis and a listing of the modal analysis computer program.

B.W.

**N85-35204*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A PRELIMINARY EVALUATION OF A FAILURE DETECTION FILTER FOR DETECTING AND IDENTIFYING CONTROL ELEMENT FAILURES IN A TRANSPORT AIRCRAFT**

W. T. BUNDICK Jul. 1985 85 p refs
(NASA-TM-87576; NAS 1.15:87576) Avail: NTIS HC A05/MF A01 CSCL 01C

The application of the failure detection filter to the detection and identification of aircraft control element failures was evaluated in a linear digital simulation of the longitudinal dynamics of a B-737 Aircraft. Simulation results show that with a simple correlator and threshold detector used to process the filter residuals, the failure detection performance is seriously degraded by the effects of turbulence.

Author

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A85-47161#**

**AN AEROELASTIC TESTING TECHNIQUE IN A STRAIGHT CASCADE WIND-TUNNEL**

E. SZECHENYI and PH. GIRAULT (ONERA, Chatillon-sous-Bagneux, France) IN: Measuring techniques for transonic and supersonic flow in cascades and turbomachines; Proceedings of the Seventh Symposium, Aachen, West Germany, September 21-23, 1983 . Aachen, Institut fuer Strahlantriebe und Turboarbeitsmaschinen, 1984, p. 4-1 to 4-8.

ONERA's straight cascade wind-tunnel situated in Modane can simulate two-dimensionally the transonic flow inside compressors at inlet Mach numbers varying from 0.5 to 1.0 and supersonic flow at Mach numbers of 1.2 and 1.4. Reynolds number simulation can be achieved by varying the tunnel pressure between the limits of 1.4 and 3 bar. The test cascade consists of six airfoil blades. Of these, the two central blades can be made to vibrate either in pitching or in heaving, though the test technique only requires one blade to vibrate. The possible frequencies of vibration are designed to simulate as far as possible the actual reduced frequencies of compressor blades. The unsteady aerodynamic measurements are made by means of pressure transducers mounted inside the airfoils. The pressure signals are treated digitally so as to give unsteady lift, moment, and pressure distributions in quasi-real time.

Author

**A85-48523**

**EUROPEAN WORKSHOP ON PROBE CALIBRATIONS**

K.-D. BROICHHAUSEN, ED. (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) and T. FRANSSON, ED. (Lausanne, Ecole Polytechnique Federale, Switzerland) Aachen, West Germany, Institut fuer Strahlantriebe und Turboarbeitsmaschinen (Mitteilung, No. 84-02), 1984, 123 p. No individual items are abstracted in this volume.

Probe calibrations are presented for wind tunnel measurements of supersonic and transonic flow in turbomachines. Consideration is given to results from recent calibrations of the WP-11 wedge probe for the following wind-tunnel parameters: pitch angle coefficient; stagnation pressure coefficient; and static pressure coefficient. The design characteristics of a cone-shaped probe, the CP-L, are discussed. Calibration diagrams are presented for CP-L measurements in different nozzle configurations. Schematic diagrams of the probe calibration rigs are provided.

I.H.

**A85-48856**
**WHY NOT HAVE A SIMULATOR TYPE FOR COMMUTER OPERATORS?**
S. ANDERSON (Rediffusion Simulation, Ltd., Crawley, England) ICAO Bulletin, vol. 40, May 1985, p. 12, 14, 15.

Almost all recurrent and conversion training can be carried out in a flight simulator, saving money and fuel, and limiting dangers of in-flight training. However, the high cost of the equipment and the lack of specific legislation have led to the exclusion of small commuters or regional operators from the use of flight simulators. The requirements and details of a projected scaled-down version of a flight simulator, advanced enough to replace the aircraft, but at a price justifiable to operators of smaller aircraft, than a commercial airliner, are discussed. The Seagull simulation computer system is described. I.S.

**A85-48857**
**CAUTRA ATC SIMULATOR STRIVES FOR REALISM**
A. PEYTAVIN (Direction Generale de l'Aviation Civile, Service Technique de la Navigation Aerienne, Paris, France) ICAO Bulletin, vol. 40, May 1985, p. 16-19.

The initial and advanced training for air traffic controllers provided by ENAC (Ecole Natitonale de l'Aviation Civile) is assisted by systematic use of the CAUTRA simulator, designed as a subsystem of the operational CAUTRA (Coordonnateur Automatique de Traffic Aerien) air traffic control system installed by ENAC in Toulouse. The CAUTRA simulator feeds simulation facilities, installed at all large French traffic control centers via the national telecommunications network. All new elements related to the airspace and aeronautical procedures that appear in the operational system are reproduced in the simulator subsystem. The components of the CAUTRA simulator, such as computers, telephony link, radar display, printers, etc., are described in detail. The School has 34 simulator positions, with a network comprising 37 remote positions. Currently 1500 exercises are available which represent 40,000 aircraft movements. The experiments carried out on the simulator may be designed to validate new airspace organization plans, the reorganization of the tasks of controllers manning a control position, or even the design of the controllers' work stations. I.S.

**A85-48858**
**ADVANCED FLIGHT TRAINING OFFERED TO CORPORATE AVIATORS**
E. J. SOWA (SimuFlite Training International, Inc., Dallas, TX) ICAO Bulletin, vol. 40, May 1985, p. 20-22.

The SimuFlite Training International flight training complex at the Dallas/Fort Worth International Airport uses new Phase-II level simulators and a new Line-Oriented Flight Training Operational approach to create realistic on-ground aircraft-flying experience. A Phase-II simulator employs a six-degree-of-freedom aircraft motion system, and accurately simulates near-ground, on-the-ground, and in-flight characteristics. It simulates the effects of crosswind, wind shear, wet and icy runway conditions and tire failures. The business-jet simulators employed at the training complex and capable of meeting the FAA Phase-II training requirements for operators of business/executive type aircraft, include SimuFlite's Learjet 35/36 system, and the simulators replicating the Learjet 55, Gulfstream III, Westwind 2, and Citation I/II. Simulators for the King Air 200 and Hawker-Siddeley 125-700 are soon scheduled for operation. I.S.

**A85-48859**
**GENERAL AVIATION NEEDS COST-EFFECTIVE FLIGHT SIMULATORS**
D. A. LOMBARDO (Frasca International, Inc., Champaign, IL) ICAO Bulletin, vol. 40, May 1985, p. 23-25.

Frasca's Models 141, 142, and 240 of fixed-wing GA aircraft, the GA helicopter simulators for Bell 206, Bell 212, and a VFR hover simulator were tested and are used in Frasca's model flight school situated at its own airport. In addition to these computer-based simulators, a new computer system, called computer interaction flight simulation (CIFS), has been recently developed under contract with NASA. In addition to normal simulator functions, CIFS provides many other possibilities. Multiple simulators, connected to a single instructor console will allow dramatically increased productivity, while the computer performs all record-keeping and grades student performance, allowing the instructor to be much more productive and creative. I.S.

**A85-49001**
**AEROSPACE SIMULATION; PROCEEDINGS OF THE CONFERENCE, SAN DIEGO, CA, FEBRUARY 2-4, 1984**
M. UNG, ED. (Southern California, University, Los Angeles) La Jolla, CA, Society for Computer Simulation (Simulation Series, vol. 13, Feb. 1984), 1984, 229 p. For individual items see A85-49002 to A85-49021.

Among the topics discussed are the simulated flight ground testing of avionics systems, recent advancements in computer image generation, rotorcraft simulation systems at NASA's Ames facility, real time structural mode simulation, the Large Amplitude Multi-Mode Aerospace Research Simulator's application to the Advanced Fighter Technology Integration F-16, the dynamics and control simulation of large space structures, and real time models of flexible space structure dynamics. Also treated are the role of simulation in the development of the fuel-efficient B 757 and B 767 airliners, modeling techniques for transonic airfoils, the principles of optimal missile guidance and control system design, guidance and control simulations for laser-guided weapons, polarimetric radar simulation, and a code for dynamic gas turbine engine models. O.C.

**A85-49002**
**FLIGHT TESTING OF AVIONIC SYSTEMS ON THE GROUND**
M. UNG (Southern California, University, Los Angeles) and J. UNDERWOOD, JR. (USAF, Edwards AFB, CA) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 3-12. refs

The Integration Facility for Avionic Systems Testing (IFAST) allows prospective U.S. Air Force avionics systems to be debugged in the course of ground-simulated flights prior to actual flight testing. IFAST uncovers problems with a given system through playback computer analysis of mission data from tapes that were recorded during simulated missions. Attention is given to IFAST's physical plant, the time-shared computer complex configuration and communications systems, and the modes of mission analysis operation. O.C.

**A85-49004**
**THE DISPLAY SUBSYSTEM IN THE AIRCRAFT SIMULATOR - SIMULATE OR STIMULATE?**
J. L. ARCHDEACON and D. B. STIMSON IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 19-26.

Since avionics display subsystems are becoming more important in advanced aircraft cockpits, display subsystem performance is of unprecedented significance. Aircraft simulators may implement such a display subsystem either by integrating the display hardware and software into the simulator, or by simulating the subsystem by means of a general purpose computer and graphics system. Attention is given to the cases of operational flight trainers, cockpit procedure trainers, and engineering simulators. O.C.

**A85-49006*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**ROTORCRAFT SIMULATION AT AMES**
T. S. ALDERETE (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 39-49. refs

Attention is given to rotorcraft simulation experience at NASA's Ames research facility, which has involved complex mathematical modeling, high computational capability requirements, and strong influences from pilot motion and visual cues. A development history and performance assessment is presented for the rotorcraft simulation hardware, together with projections of near term development improvements of capabilities. Greater demand is anticipated for the simulation of all-digital helicopter flight control systems. O.C.

**A85-49019**

### ADVANCES IN FLIGHT SIMULATORS

J. A. SCHEPP (Singer Co., Link Flight Simulation Div., Binghamton, NY) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 192-206.

The primary impact of microprocessor development on flight training simulator design may be the encouragement of system architecture configurations in which computational functions associated with each major system are decoupled from each other. The systems are then complete with respect to both hardware and software; the only remaining links between simulator subdivisions are the paths by which common data are transmitted between major functions in a clearly identified and controlled global bus system. O.C.

**A85-49020**

### THE HISTORY AND FUTURE CONTRIBUTIONS OF CARCO SIMULATORS TO THE AEROSPACE INDUSTRY

J. M. CARTER (Carco Electronics, Menlo Park, CA) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 207-211.

A development history is presented for three-axis flight simulators designed for use in manned spacecraft and high performance missile and aircraft-related development programs. In order to satisfy gimbal stiffness, high mechanical resonance, good mechanical damping and low inertia, simulator gimbals fabricated from magnesium are used. Analog control systems remain popular with many users of these simulators. O.C.

**A85-49906**

### APPLYING SHEAR BEAM LOAD MEASURING TECHNIQUES TO PORTABLE PLATFORM SCALES FOR AIRCRAFT WEIGHING

H. NELSON (WEICO Corp., Lynnwood, WA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 18 p.
(SAWE PAPER 1581)

An Aircraft Weighing System (AWS), in which the load weight is measured by sensitive shear deflection in the weighing platform structure, is described. Five portable components, the number of each determined by the types of aircraft to be weighed, compose the AWS: the platform scales, the scale access ramps, the spacer platforms, the cable assemblies, and the digital system electronics. One cable assembly connects each scale to the computer, which provides prompts, displays the gross weight to within 0.10 percent and the center of gravity to within 0.20 percent on the alpha-numeric display unit, and provides a printed record. The computer can also interface with the on-board WBTMS for the purpose of calibration from the ground, by use of a special interface card. Block diagrams are included. I.S.

**A85-49908**

### THE ROLE OF LOAD-CELL ROTATION IN AIRPLANE-WEIGHT DETERMINATION

E. J. GAUTHIER (Boeing Commercial Airplane Co., Seattle, WA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 7 p.
(SAWE PAPER 1583)

Attention is given to a method of determining acceptable accuracy limits for an aircraft weighing test, and applying the acceptance criteria in such a way as to determine whether test results are acceptable or indicate that testing should continue. Acceptance testing includes a weighing process that involves physically moving the scales along the airplane jack points between the individual weighings. In multiple weighings, weight will appear to change and the center of gravity will appear to move; an analysis of the system allows the correlation of apparent center of gravity movement with weighing accuracy. O.C.

**A85-49947**

### SHOULD THEY FEEL JUST LIKE FLYING?

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Sept. 1985, p. 9-15.

General capabilities and limitations of the existing ground-based flight simulators are reviewed. Attention is paid to synergistic six-degrees-of-freedom systems, Large-Amplitude Multimode Aerospace Simulator (LAMARS)-type systems, and the centrifuge-based Dynamic Flight Simulator (DFS). Their relative merits, such as the g onset rates, versatility, and complexity are discussed. The discussion also covers military rotorcraft simulators, which are capable of reproducing the nap-of-the-earth mission and low-altitude formation flights environment. Finally, the U.S. Air Force's Total In-Flight Simulator and the NT-33A in-flight simulator are described. L.T.

**A85-49948**

### SIMULATORS - HOW REAL DOES THE VISUAL SYSTEM NEED TO BE?

D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 5, Sept. 1985, p. 16-22.

An assessment is made of the degree of realism obtainable by means of computer-generated imagery (CGI) in state-of-the-art military aircraft mission simulators. CGI allows geographic data obtained from the U.S. Defense Mapping Agency or other intelligence sources to be programmed and projected in visually realistic terms, so that the pilot using the simulator can fly through a given region and get a strong sense of the terrain and other surface features; enemy tanks and aircraft, moreover, can be superposed on the given landscape to give a full combat scenario. O.C.

**N85-35205** Texas Univ., Austin.

### A STUDY OF THE CONTROL OF PARTICULATE EMISSIONS FROM TURBINE ENGINE TEST CELLS Ph.D. Thesis

J. E. STEVENS, JR. 1984 197 p
Avail: Univ. Microfilms Order No. DA8508364

The United States Air Force has been cited in California for violation of visible opacity standards by the test cell buildings used for aircraft engine run-up during major engine overhaul. Recommendations to control emissions by conventional means, such as electrostatic precipitation or high-energy scrubbers with demisters, were deemed non-cost-effective (130 test cells at more than 1 million dollars per cell). As an alternative control measure, EPA Method 5 particulate sampling was used to characterize stack emissions during the incremental addition of cooling water to the engine exhaust/augmentator air discharge. Six water increments, from 230 (baseline) to 1200 gallons per minute, were tested. Increasing water injection rates to 801 gallons per minute significantly reduced engine-contributed test cell emissions for the J75-17 engine to 0.05 pounds particulate per million Btu. Water injection at 801 gallons per minute therefore represents the best available control technology for turbine engine test cells testing the J75 engine. Dissert. Abstr.

**N85-35208#** Naval Surface Weapons Center, White Oak, Md.

### MACH 14 FLOW RESTRICTOR THERMAL STRESS ANALYSIS Final Report, Jan. - Apr. 1984

E. J. BECKER Aug. 1984 380 p Original contains color illustrations
(AD-A156215; NSWC/TR-84-364) Avail: NTIS HC A17/MF A01 CSCL 14B

The objective of this study was to determine the effects of heating and mechanical pressure loading on the flow restrictor plate used in the Mach 14 leg of NSWC/WO hypervelocity Wind Tunnel. Included in this report are the procedures for model generation using PATRAN-G, model translation into ABAQUS format, transient heat transfer analysis, thermal stress analysis, results translation from ABAQUS to PATRAN-G, and the method used to determine the heat transfer film coefficients needed for

ABAQUS. The results of these analyses are reviewed and recommendations are made for future analyses. GRA

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## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A85-47057**
**IUS-1 - REDUNDANT INERTIAL MEASUREMENT UNIT TEST PLAN AND RESULTS**
L. W. MUELLER, L. DUBBERKE (Aerospace Corp., Los Angeles, CA), and J. VOLGER (USAF, Space Div., Los Angeles, CA) IN: Aerospace Applications Conference, Vail, CO, January 28-February 4, 1984, Digest . New York, IEEE, 1984, p. 59-77.

The Redundant Inertial Measurement Unit (RIMU) of the Inertial Upper Stage (IUS) rocket of the Shuttle has been tested according to a plan developed jointly by NASA and the USAF. The tests were carried out at the Eastern Launch Site (ELS) 16 hours before launch and consisted of five on pad calibrations and alignments (cal/aligns). RIMU gyrocompass alignments were compared to a reference optical alignment, and trend data were calculated. Comparison of the trend data showed that the difference between the RIMU cal/aligns and the reference alignments was within the maximum allowable range of error of + or - 325 arcsec. The location of the RIMU in the IUS avionics bay is shown in a diagram. I.H.

**A85-47306**
**MINIMAX OPTIMAL CONTROL AND ITS APPLICATION TO THE REENTRY OF A SPACE GLIDER**
A. MIELE and P. VENKATARAMAN (Rice University, Houston, TX) IN: Recent advances in the aerospace sciences . New York, Plenum Press, 1985, p. 21-40. refs
(Contract NSF ENG-79-18667)

Minimax problems of optimal control are presently converted into Mayer-Bolza problems of the calculus of variations by means of a transformation technique that requires the proper augmentation of the state vector, the control vector, and the parameter vector, as well as the proper augmentation of the constraining relations. By means of this transformation, the unknown minimax value of the performance index becomes a component of the vector parameter. Numerical results are obtained by means of the sequential gradient-restoration algorithm for solving optimal control problems on digital computers; attention is given to the hypervelocity regime in an exponential atmosphere, for a reentry glider whose trajectory is controlled by means of the angles of attack and banking. O.C.

**A85-49016*** National Aeronautics and Space Administration. Johnson (Lyndon B.) Space Center,
**SOME REAL-TIME SIMULATION APPLICATIONS TO SPACE SHUTTLE APPROACH AND LANDING DESIGN AND TEST**
H. G. LAW, III and H. W. STEGALL (NASA, Johnson Space Center, Houston, TX) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 155-170. refs

In the present discussion of the roles played by real time, man-in-the-loop engineering simulation in the development of NASA Space Shuttle approaches and landings, attention is given to the function of the simulator as a design and verification tool. Aspects of the problem posed by Shuttle landings, and the difficulties involved in this problem's quantification, are noted. Recent results of control system studies for pitch axis control, using fixed- and motion-base simulators, are discussed. O.C.

**A85-49435**
**DESCENT VEHICLES [SPUSKAEMYE APPARATY]**
B. M. PANKRATOV Moscow, Izdatel'stvo Mashinostroenie, 1984, 232 p. In Russian. refs

The work examines the current status of design methods (including CAD) used in the development of descent vehicles intended for landing on planets of the solar system and for return to earth from orbits and interplanetary trajectories. The appropriate aerodynamic schemes are analyzed, and attention is given to methods for determining the main design parameters for ballistic, gliding, and sliding descent vehicles. Problems of thermal protection are discussed, and strength calculations are presented for fuel, instrument-payload, and engine systems. Finally, the use of a specially constructed descent vehicle to simulate the entry of a meteoroid into the earth's atmosphere is considered. B.J.

**A85-49448**
**ORBIT CONTROL OF A SYNCHRONOUS SATELLITE [UPRAVLENIE ORBITOI STATSIONARNOGO SPUTNIKA]**
G. M. CHERNIAVSKII, V. A. BARTENEV, and V. A. MALYSHEV Moscow, Izdatel'stvo Mashinostroenie, 1984, 144 p. In Russian. refs

The choice of a control strategy for the transfer of a synchronous satellite (SS) from the injection longitude to the operating longitude is considered. Attention is given to methods for controlling the longitudinal and latitudinal position of an SS with an accuracy that meets international standards. Particular consideration is given to the change in stationary-orbit elements under impulse control, the use of low thrust to transfer an SS, and stabilization of the orbital position of an SS. B.J.

**N85-35223*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.
**RESULTS OF TESTS OF THE SRB AFT SKIRT HEAT SHIELD CURTAIN IN THE MSFC HOT GAS FACILITY**
W. G. DEAN Feb. 1982 64 p refs
(Contract NAS8-32982)
(NASA-CR-170888; NAS 1.26:170888; LMSC-HREC-TM-D784643)
Avail: NTIS HC A04/MF A01 CSCL 21H

During the first two space shuttle flights the aft skirt heat shield curtain performed well during ascent but failed during reentry. This exposed the inside of the skirt and its subsystems to reentry heating. The resulting exposure damaged various expensive systems items and therefore a curtain reassessment is required. As a part of this reassessment, tests were conducted in the MSFC Hot Gas Facility (HGF). The purposes of these tests were to determine if the curtain would fail in a manner similar to that in flight and to demonstrate that meaningful tests of the curtain can be conducted in the HGF. Author

**N85-35224*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.
**RESULTS OF TESTS OF MTA-2 TPS ON THE SRB HOLD-DOWN BOLT BLAST CONTAINER**
W. G. DEAN 30 Jun. 1982 13 p
(Contract NAS8-32982)
(NASA-CR-170891; NAS 1.26:170891; LMSC-HREC-TN-D867571)
Avail: NTIS HC A02/MF A01 CSCL 21H

The four solid rocket booster (SRB) hold-down posts are fastened to the mobile launch platform (MLP) with four large nuts. At liftoff the nuts are split with explosive changes to release the SRB/Shuttle. A blast container is placed over the nuts to protect the vehicle from flying debris. The blast container is a reusable part and has to be protected from aerodynamic heating during flight. The thermal protection system (TPS) used to protect these blast containers is cork. Fitting the flat cork sheet to this hemispherical shaped blast container is both time consuming and expensive. Another problem is removing the charred cork and epoxy glue from the blast containers. Replacements of this cork with another TPS material such as MTA-2 was examined. Heating rates along the centerline of the forward facing areas of the blast container were determined. The feasibility of using 1/2 in. MTA-2 on the SRB blast containers for protection from ascent, plume impingement and reentry heating is demonstrated. E.A.K.

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## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A85-47973**

**EFFECT OF TEMPERATURE ON THE FATIGUE AND FRACTURE PROPERTIES OF 7475-T761 ALUMINUM**

J. M. COX, D. E. PETTIT, and S. L. LANGENBECK (Lockheed-California Co., Burbank) IN: Fatigue at low temperatures; Proceedings of the Symposium, Louisville, KY, May 10, 1983 . Philadelphia, PA, ASTM, 1985, p. 241-256. refs

The effect of low-temperature toughness degradation on damage tolerance and life analysis methodology is discussed. Spectrum fatigue and fatigue crack growth tests were conducted and life predictions made on 7475-T761 aluminum. The retardation behavior was determined by conducting constant K single overload fatigue crack growth tests. The low-temperature environment (-54 C) improved the life of fatigue and fatigue crack growth tests subjected to several loading spectra. This may be partially attributable to stronger retardation effects at low temperatures. It is concluded that low temperature may be a factor in damage tolerance and life analysis only under certain conditions. Author

**A85-47974**

**LOW TEMPERATURE AND LOADING FREQUENCY EFFECTS ON CRACK GROWTH AND FRACTURE TOUGHNESS OF 2024 AND 7475 ALUMINUM**

P. R. ABELKIS, M. B. HARMON, E. L. HAYMAN, T. L. MACKAY (Douglas Aircraft Co., Long Beach, CA), and J. ORLANDO IN: Fatigue at low temperatures; Proceedings of the Symposium, Louisville, KY, May 10, 1983 . Philadelphia, PA, ASTM, 1985, p. 257-273. Research sponsored by the McDonnell Douglas Independent Research and Development Program. refs

An experimental program was conducted to investigate the effect of low temperature (219 K) on the crack growth and fracture toughness of two aluminum alloys, 2024-T351 and 7475-T7651. Crack growth tests were performed with center-cracked panels and constant-amplitude and spectrum loadings. The spectrum represented a transport wing lower surface. The results show the 2024 alloy properties at low temperature to be equal to or better than the properties of that alloy at room temperature (RT), whereas some of the 7475 alloy properties decreased. In addition, tests were performed at RT and low temperature on 2024-T3 to evaluate the effect of loading frequency on crack growth. The results indicated a faster crack growth rate at lower frequencies. Author

**A85-48274*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

**SUPERALLOY MICROSTRUCTURAL VARIATIONS INDUCED BY GRAVITY LEVEL DURING DIRECTIONAL SOLIDIFICATION**

M. H. JOHNSTON, P. A. CURRERI, R. A. PARR, and W. S. ALTER (NASA, Marshall Space Flight Center, Huntsville, AL) Metallurgical Transactions A - Physical Metallurgy and Materials Science (ISSN 0360-2133), vol. 16A, Sept. 1985, p. 1683-1686. refs

The Ni-base superalloy MAR-M246 (Hf) was directionally solidified during low gravity maneuvers aboard a NASA KC-135 aircraft. Gravity force variations during this process yielded a concomitant variation in microstructure and microsegregation. Secondary dendrite arm spacings are noted to be larger in the low-g portion; this, in turn, decreases the extent of interdendritic segregation. The amount of Hf in both the carbides and interdendritic eutectic increases as the gravity force diminishes. Fewer carbides are present in the low-g regions. O.C.

**A85-48562**

**FIBRE REINFORCED COMPOSITES '84; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, UNIVERSITY OF LIVERPOOL, ENGLAND, APRIL 3-5, 1984**

Conference sponsored by the Plastics and Rubber Institute. London, Plastics and Rubber Institute, 1984, 332 p. For individual items see A85-48563 to A85-48574.

Among the topics discussed are phenolic resin matrix composites for high temperature and fire-exposure applications, novel resins for fiber-reinforced composite productivity improvement, the use of engineering textiles for mechanical property improvement in composites, the significance of aramid fiber reinforcement in composites, the energy absorption properties of Sheet Metal Compounds (SMCs) under crash conditions, and SMC impact behavior variations with temperature. Also covered are CFRP applications in high performance structures, composite helicopter main rotor blade technology, composite vehicular leaf springs, carbon fiber-reinforced thermoplastics, filament winding development status, the injection processing of fiber-reinforced thermoplastics, civil aircraft composite structure certification, composite radomes, design procedures for short fiber-reinforced thermoplastics, the strength limitations of mechanically fastened lap joints, environmental fatigue and creep in glass-reinforced materials, the effects of moisture on high performance laminates, the environmental behavior of SMC, and corrugated composites. O.C.

**A85-48568**

**APPLICATION OF CARBON FIBRE REINFORCED THERMOPLASTIC (PEEK) COMPOSITE TO AERO ENGINE COMPONENT MANUFACTURE**

G. A. OWENS and D. J. LIND (Rolls-Royce, Ltd., Derby, England) IN: Fibre reinforced composites '84; Proceedings of the International Conference, Liverpool, England, April 3-5, 1984 . London, Plastics and Rubber Institute, 1984, p. 12.1-12.11. refs

Comparative physical and mechanical property data is presented and discussed for various thermoplastic and thermoset polymers and their carbon fiber reinforced composites. The potential advantages offered by PEEK Aromatic Polymer Composites (APC) and their current limitations for use in aero engine applications are outlined. In order to assess the advantages and the problems to be overcome in using such material, a preliminary evaluation program is described involving the manufacture of a nonstructural aero engine component. Author

**A85-48572**

**CONTINUOUS FIBRE REINFORCED THERMOPLASTICS IN NEW GENERATION RADOMES**

C. K. HALL (British Aerospace, PLC, Dynamics Group, Stevenage, England) IN: Fibre reinforced composites '84; Proceedings of the International Conference, Liverpool, England, April 3-5, 1984 . London, Plastics and Rubber Institute, 1984, p. 19.1-19.13. Research supported by British Aerospace, PLC. refs

The paper discusses the use of thermoplastics for radome applications. The thermoplastics examined are those grouped generically as polyarylates, and in particular polyetheretherketone (PEEK). Properties of the matrices and reinforcements are given, and the four elements of radome design considerations are discussed: electrical, structural, environmental and manufacture. The manufacturing process utilizes modified stacking techniques and press moulding for glass fiber composites and powder sintering for PEEK syntactic foams. Author

**A85-48758**

**THERMAL STABILITY OF PLASMA-SPRAYED ZIRCONIA COATINGS AS RELATED TO SUBSTRATE SELECTION**

F. VASILIU, I. PENCEA, V. MANOLIU, I. DINCA (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Romania), and C. SARBU (Institute for Physics and Technology of Materials, Bucharest, Romania) American Ceramic Society Bulletin (ISSN 0002-7812), vol. 64, Sept. 1985, p. 1268-1271. refs

Plasma-sprayed zirconia coatings deposited on refractory substrates (Ni superalloys, AISI 314 steel) were subjected to thermal cycling tests to evaluate the influence of substrate selection on the thermal stability of the coating. The Y2O3and MgO-stabilized ZrO2 coatings, in general, perform better than CaO-stabilized coatings. The degradation and failure of a given thermal barrier system depends on the substrate used. Thermal cycling data are discussed in connection to the results of SEM and X-ray mapping investigations. Possible reasons for premature spalling of stabilized ZrO2 coatings on certain substrates are suggested. Author

**A85-49901**
**ADHESIVE SEALING FOR INTEGRAL FUEL TANKS**
F. W. AULD (General Dynamics Corp., Fort Worth, TX) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 14 p.
(SAWE PAPER 1573)

A significant degree of weight reduction was recently achieved for the F-16 fighter's integral fuel tanks in the course of a manufacturing technology development program. This two-part effort involved, first, the modification and evaluation of the existing 'Scotch-Weld' system to verify performance improvements obtainable at lower manufacturing costs. Then, two full scale fuselage integral fuel tank assemblies were sealed with the new product and subjected to a comprehensive cost comparison study without a break in the production flow. O.C.

**A85-49905**
**THE WEIGHT REDUCTION POTENTIAL OF ADVANCED COMPOSITES**
P. W. SCOTT (Douglas Aircraft Co., Long Beach, CA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 18 p. refs
(SAWE PAPER 1579)

Attention is given to the weight-reduction potential of carbon/epoxy tape and cloth, Kevlar/epoxy cloth, and boron/epoxy tape, in various ply arrangements. These advanced composites are compared to aluminum and E-glass epoxy performance under compression and shear loading. Tension-loaded structural weights are also compared, assuming damage tolerance criteria, and an analysis is conducted for those cases in which rigidity is critical for deflection and/or flutter considerations. Forty cases of aircraft structural components that were first constructed of conventional materials and then redesigned using advanced composites, thereby yielding empirical weight reduction data, are evaluated in light of analytical weight reduction potentials. O.C.

**A85-50116**
**CERTIFICATION OF RECIPROCATING ENGINE AIRCRAFT OILS AND ADDITIVES BY SUPPLEMENTAL TYPE CERTIFICATION PROCEDURES**
W. E. GARRELTS and H. A. POITZ (Illinois, University, Urbana) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 10 p. refs
(SAE PAPER 850899)

The steps of the process by which an aircraft piston engine oil is developed and certified are traced, from its origin in the perception of a need for an oil possessing improved characteristics, through development to the standards set by existing specifications, to testing which yields manufacturers' approval and FAA certification, and finally, marketing. Emphasis is given to current difficulties in the achievement of 150-hour oil qualification engine tests, as well as to relative cost of an oil's approval procedure. O.C.

**N85-34222*#** Sikorsky Aircraft, Stratford, Conn.
**FLIGHT SERVICE EVALUATION OF COMPOSITE HELICOPTER COMPONENTS Contractor Final Report, May 1982 - Sep. 1983**
M. J. RICH and D. W. LOWRY Apr. 1985 116 p refs
(Contract NAS1-16542)
(NASA-CR-172562; NAS 1.26:172562; SER-510117) Avail: NTIS HC A06/MF A01 CSCL 11D

An assessment of composite helicopter structures, exposed to environmental effects, after four years of commercial service is presented. This assessment is supported by test results of helicopter components and test panels which have been exposed to environmental effects since late 1979. Full scale static and fatigue tests are being conducted on composite components obtained from S-76 helicopters in commercial operations in the Gulf Coast region of Louisiana. Small scale tests are being conducted on coupons obtained from panels being exposed to outdoor conditions in Stratford, Connecticut and West Palm Beach, Florida. The panel layups represent S-76 components. Moisture evaluations and strength tests are being conducted, on the S-76 components and panels, over a period of eight years. Results are discussed for components and panels with up to four years of exposure. Author

**N85-34279#** Rolls-Royce Ltd., Derby (England).
**DIRECTIONALLY SOLIDIFIED GAS TURBINE ALLOYS**
P. R. BEELEY (Leeds Univ.) and D. DRIVER 1 Feb. 1985 51 p refs
(PNR-90264) Avail: NTIS HC A04/MF A01

Progress in directional solidification of superalloys, and applications to aircraft engine turbine blades are reviewed. Superalloy metallurgy and blade design; casting techniques for directional solidification; alloy development for conventional casting; and single crystal alloys are discussed. Author (ESA)

**N85-34280*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**FIRE-RESISTANT PHOSPHORUS CONTAINING POLYIMIDES AND COPOLYIMIDES Patent**
J. A. MIKROYANNIDIS, inventor (to NASA) (National Academy of Sciences - National Research Council, Washington, D.C.) 20 Aug. 1985 12 p Filed 16 Aug. 1984 Supersedes N85-21363 (23 - 12, p 1812) Continuation-in-part of US-Patent-Appl-SN-522629, 12 Aug. 1983
(NASA-CASE-ARC-11522-2; US-PATENT-4,536,565; US-PATENT-APPL-SN-641143; US-PATENT-CLASS-528-352; US-PATENT-CLASS-528-168; US-PATENT-CLASS-528-229; US-PATENT-CLASS-528-353) Avail: US Patent and Trademark Office CSCL 11C

Phosphorus-containing polyimides and copolyimides are synthesized in a two-step polycondensation reaction from 1-(diorganooxyphosphonl)methly 2,4- and 2,6-diaminobenzenes and tetracarboxylic anhydride. The diorgano position of the diorganooxyphosphonyl group includes alkyl, such as ethyl, substituted alkyl, such as 2-chloroethyl, and aryl such as phenyl. The tetracarboxylic anhydries include compounds such as pyromellitic dianhydride and benzophenone tetracarboxylic dianhydride. The glass transition temperature (Tg) of the polyimides is reduced by incorporation of the (dialkoxyphosphonyl)methyl groups. The phosphorus-containing copolyimides show a considerably higher degree of fire-resistance as compared to that of the corresponding common polyimides.
Official Gazette of the U.S. Patent and Trademark Office

**N85-34295*#** Akron Univ., Ohio. Dept. of Chemical Engineering.
**MEASUREMENT AND CORRELATION OF JET FUEL VISCOSITIES AT LOW TEMPERATURES Final Report**
D. L. SCHRUBEN Aug. 1985 31 p refs
(Contract NAG3-488)
(NASA-CR-174911; NAS 1.26:174911) Avail: NTIS HC A03/MF A01 CSCL 21D

Apparatus and procedures were developed to measure jet fuel viscosity for eight current and future jet fuels at temperatures from ambient to near -60 C by shear viscometry. Viscosity data showed good reproducibility even at temperatures a few degrees below the measured freezing point. The viscosity-temperature relationship could be correlated by two linear segments when plotted as a standard log-log type representation (ASTM D 341). At high temperatures, the viscosity-temperature slope is low. At low temperatures, where wax precipitation is significant, the slope is higher. The breakpoint between temperature regions is the filter flow temperature, a fuel characteristic approximated by the freezing point. A generalization of the representation for the eight experimental fuels provided a predictive correlation for

**low-temperature viscosity, considered sufficiently accurate for many design or performance calculations.**
E.A.K.

**N85-35233*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**THERMAL BARRIER COATING SYSTEM Patent**
S. STECURA, inventor (to NASA) 13 Aug. 1985 5 p Filed 14 Aug. 1984 Supersedes N84-33595 (22 - 23, p 3724) Continuation-in-part of US Patent-4,485,151, US Patent-Appl-SN-523297, filed 16 Aug. 1983, and continuation-in-part of abandoned US Patent-Appl-SN-375784, filed 6 May 1982
(NASA-CASE-LEW-14057-1; US-PATENT-4,535,033; US-PATENT-4,485,151; US-PATENT-APPL-SN-640712; US-PATENT-APPL-SN-523297; US-PATENT-APPL-SN-375784; US-PATENT-CLASS-428-633; US-PATENT-CLASS-428-656; US-PATENT-CLASS-428-678; US-PATENT-CLASS-428-679; US-PATENT-CLASS-428-680; US-PATENT-CLASS-428-681; US-PATENT-CLASS-428-682) Avail: US Patent and Trademark Office CSCL 11D

An oxide thermal barrier coating comprises ZrO3-Yb2O3 that is plasma sprayed onto a previously applied bond coating. The zirconia is partially stabilized with about 124 w/o ytterbia to insure cubic, monoclinic, and terragonal phases.
Official Gazette of the U.S. Patent and Trademark Office

**N85-35236*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.
**SRB THERMAL PROTECTION SYSTEMS MATERIALS TEST RESULTS IN AN ARC-HEATED NITROGEN ENVIRONMENT**
C. J. WOJCIECHOWSKI Aug. 1979 62 p refs
(Contract NAS8-32982)
(NASA-CR-170881; NAS 1.26:170881; LMSC-HREC-TM-D697766) Avail: NTIS HC A04/MF A01 CSCL 11D

The external surface of the Solid Rocket Booster (SRB) will experience imposed thermal and shear environments due to aerodynamic heating and radiation heating during launch, staging and reentry. This report is concerned with the performance of the various TPS materials during the staging maneuver. During staging, the wash from the Space Shuttle Main Engine (SSME) exhust plumes impose severe, short duration, thermal environments on the SRB. Five different SRB TPS materials were tested in the 1 MW Arc Plasma Generator (APG) facility. The maximum simulated heating rate obtained in the APG facility was 248 Btu/sq ft./sec, however, the test duration was such that the total heat was more than simulated. Similarly, some local high shear stress levels of 0.04- psia were not simulated. Most of the SSME plume impingement area on the SRB experiences shear stress levels of 0.02 psia and lower. The shear stress levels on the test specimens were between 0.021 and 0.008 psia. The SSME plume stagnation conditions were also simulated.
B.W.

**N85-35237*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.
**RESULTS OF VARIABLE ENTHALPY TESTS OF CPR-488 TIP PANELS IN MSFC HOT GAS FACILITY**
W. G. DEAN 22 Feb. 1982 37 p
(Contract NAS8-32982)
(NASA-CR-170889; NAS 1.26:170889; LMSC-HREC-TM-D784773) Avail: NTIS HC A03/MF A01 CSCL 11D

Tests were conducted to determine the effects of variable enthalpy levels on CPR-488 foam performance and/or recession. Also to be determined was whether the BX-250 thickness indicator plugs (TIP) concept is feasible for measuring recession rates of CPR-488 foam during external tank flight. The tests determined that the TIP plug idea works. The accuracy of the indicated recession depth is approximately + or - 1.16 in. The BX-250 plugs with TiO2 work better than the regular BX-250 plugs. Also, there is an effect of enthalpy on CPR-488 foam performance.
E.R.

**N85-35239*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.
**RESULTS OF TESTS OF WEATHERED K5NA CLOSEOUT MATERIAL IN THE MSFC HOT GAS FACILITY**
W. G. DEAN 6 Aug. 1982 24 p
(Contract NAS8-32982)
(NASA-CR-170893; NAS 1.26:170893; LMSC-HREC-TN-D867576) Avail: NTIS HC A02/MF A01 CSCL 11D

The application of K5NA over hypolon was investigated. The effects of using K5NA over painted cork surfaces, the effects of weathering on the unpainted K5NA surfaces are determined, and the use of water versus solvent for tooling K5NA in place were compared. It is concluded that: (1) K5NA can be applied to hypalon surfaces; (2) K5NA can be left unpainted; and (3) K5NA can be tested with water or solvent.
E.A.K.

**N85-35241*#** Lockheed-California Co., Burbank.
**FUEL CONTAINMENT AND DAMAGE TOLERANCE FOR LARGE COMPOSITE PRIMARY AIRCRAFT STRUCTURES. PHASE 1: TESTING Contractor Report, Oct. 1981 - Jan. 1983**
J. P. SANDIFER Mar. 1983 501 p refs
(Contract NAS1-16856)
(NASA-CR-166091; NAS 1.26:166091; LR-30380-PHASE-1) Avail: NTIS HC A22/MF A01 CSCL 11D

Technical problems associated with fuel containment and damage tolerance of composite material wings for transport aircraft were identified. The major tasks are the following: (1) the preliminary design of damage tolerant wing surface using composite materials; (2) the evaluation of fuel sealing and lightning protection methods for a composite material wing; and (3) an experimental investigation of the damage tolerant characteristics of toughened resin graphite/epoxy materials. The test results, the test techniques, and the test data are presented.
E.A.K.

**N85-35257#** Dayton Univ., Ohio.
**ASPECTS OF HIGH-RESOLUTION GAS CHROMATOGRAPHY AS APPLIED TO THE ANALYSIS OF HYDROCARBON FUELS AND OTHER COMPLEX ORGANIC MIXTURES. VOLUME 1 Final Report, Jan. - Sep. 1980**
W. A. RUBEY Wright-Patterson AFB, Ohio AFWAL Feb. 1985 213 p
(Contract F33615-77-C-2004)
(AD-A156154; UDR-TR-82-156-VOL-1; AFWAL-TR-84-2096-VOL-1) Avail: NTIS HC A10/MF A01 CSCL 21D

Turbine engine fuels are complex mixtures of hydrocarbons which have until recently, been obtained almost exclusively from petroleum. There is growing interest in developing alternative feedstocks for the eventual production of high-quality turbine engine fuels. The major analytical technique for separating the chemical constituents and analyzing fuels and synfuel feedstocks is high-resolution gas chromatography (HRGC), and the extreme chemical complexity of these hydrocarbon mixtures continues to challenge even the most sophisticated HRGC techniques. Therefore, the principal objective of this research was to identify and evaluate advanced HRGC instrumental procedures which show potential for improving the analysis of hydrocarbon jet fuels and various feedstocks. A gas chromatograph can be viewed as an assembly of individual components arranged to form a time invariant linear system. Accordingly, a systems approach has been used in this investigation to study, refine, and modify HRGC instrumentation.
GRA

**N85-35308#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**NITROGEN ANALYSIS BY CHEMILUMINESCENCE Final Report, Aug. 1982 - Dec. 1983**
R. C. STRIEBICH Apr. 1985 37 p
(AD-A156197; AFWAL-TR-84-2089) Avail: NTIS HC A03/MF A01 CSCL 21D

With high overall accuracy, a chemiluminescent detector can easily measure low ppm nitrogen levels in model mixtures and shale-derived jet fuel distillates. Forty model mixtures were analyzed

using an Antek Model 720C chemiluminescent detector to demonstrate the absolute accuracy and precision of the instrument. A severely hydrotreated shale JP-4 jet fuel was blended with selected model mixtures to obtain six fuels ranging from less than 1 to approximately 150 parts-per-million added nitrogen. Total nitrogen analysis was then accomplished by two different chemiluminescent detection systems, as well as by the micro-Kjeldahl and microcombustion methods. Results clearly point out the ability of the chemiluminescent method to measure the nitrogen level of low ppm shale-derived aviation turbine fuel.
GRA

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## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A85-47060**

**A WIDEBAND X100 LOW NOISE MICROWAVE FREQUENCY MULTIPLIER**

H. ENDLER (Systron Donner Corp., Microwave Div., Van Nuys, CA) IN: Aerospace Applications Conference, Vail, CO, January 28-February 4, 1984, Digest . New York, IEEE, 1984, p. 107-116.

A low-noise X100 frequency multiplier chain has been built for use in an airborne radar exciter/downconverter assembly. The input frequency band is 91-94 MHz, and the output frequency band is 9100-9400 MHz. The integrated downconverter assembly includes: dual receiver channels made from low-noise GaAs FETs; X-band preamplification; intermediate frequency filtering; and amplification. The entire assembly is packaged for installation in combat aircraft and occupies less than 135 cubic inches. The phase noise spectral density of the X100 multiplier is given for various frequencies in the range 1 MHz-100 Hz. Black and white photographs of the exciter downconverter assembly are provided.
I.H.

**A85-47082**

**A NEW SINGLE FILAMENT SMOKE TUBE INJECTION DEVICE**

T. J. MUELLER, R. C. NELSON, J. T. KEGELMAN, and R. J. ZEHENTNER (Notre Dame, University, IN) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 45-48. refs

A new mechanism for introducing smoke into a wind tunnel which was devised to study forced and natural boundary layer transition around axisymmetric bodies is described. Previous devices had three fundamental short-comings: pulsating action of the smoke, nonuniform smoke, and a temperature difference between the smoke and the air in the tunnel, which caused the smoke to rise. The new design uses a trombone ball device with a relatively large contraction ratio. The smoke entering the contraction cone passes through a honeycomb and enters the settling chamber. The resulting smoke stream is extremely uniform and free of pulsations. The smoke temperature is closer to the ambient temperature, significantly reducing the 'roll-up' problem.
C.D.

**A85-47085**

**FLOW CONES FOR AIRPLANE FLIGHT TEST FLOW VISUALIZATION**

J. P. CROWDER and P. E. ROBERTSON (Boeing Commercial Airplane Co., Seattle, WA) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 60-64.

Flow Cones, a newly developed improvement on the standard tuft method used in flight testing, are discussed. The shortcomings of the tuft method which Flow Cones were designed to overcome are reviewed, and Flow Cones are described. Several different applications of retroreflective Flow Cones are shown and described, including Flow Cones on an aircraft wing during a stall, air-to-air imaging using Flow Cones, and the detection of separation on the rotor surface of a wind turbine.
C.D.

**A85-47090**

**USE OF TITANIUM TETRACHLORIDE FOR VISUALIZATION OF ACCELERATING FLOW AROUND AIRFOILS**

P. FREYMUTH, W. BANK, and M. PALMER (Colorado, University, Boulder) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 99-105. refs
(Contract AF-AFOSR-81-0037)

The use of titanium tetrachloride for the visualization of airflows is described. Safety aspects and photographic techniques are considered. Examples of accelerating flow around an airfoil are shown exhibiting the complexity and beauty of unsteady flows.
Author

**A85-47099**

**FLOW VISUALIZATION USING COMPUTER-GENERATED COLOR VIDEO DISPLAYS OF FLOW FIELD SURVEY DATA**

A. E. WINKELMANN and C. P. TSAO (Maryland, University, College Park) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 175-179.

A computer driven color video display technique has been developed for the presentation of wind tunnel flow field survey data. The results of both qualitative and quantitative flow field surveys can be presented in high spatial resolution color coded displays. The display of data in this manner can be considered to be a new type of flow visualization. The technique enables one to present and interpret vast quantities of data which heretofore would have been difficult or impossible to comprehend. The technique has been used to display data obtained with a variety of wind tunnel type probe sensors, including hot-wire probes, pitot tubes, 5 and 7-tube pressure probes and a single channel laser velocimeter.
Author

**A85-47106*** Stanford Univ., Calif.

**THREE-DIMENSIONAL TOMOGRAPHIC RECONSTRUCTION OF THE FLOW AROUND A REVOLVING HELICOPTER ROTORBLADE - A NUMERICAL SIMULATION**

L. HESSELINK and R. SNYDER (Stanford University, CA) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 213-220.
(Contract NCC2-188)

This paper discusses tomographic data acquisition and reconstruction procedures for determining the flow around a revolving helicopter rotor blade. The data acquisition procedure is simulated using, as a testbed, a numerical representation of the flow and projections through this known field are computed. An investigation has been made of: (1) the effect of the number of projections on the accuracy of the reconstruction and (2) the fidelity of the reconstruction when the region of intersection of all projections is smaller than the spatial extent of the flow.
Author

**A85-47127**

**THE USE OF VISUALIZATION AS A GUIDE IN THE NUMERICAL DETERMINATION OF THE FLOW AROUND AN ABRUPTLY ACCELERATED ELLIPTIC CYLINDER OR AIRFOIL**

P. MONNET, M. COUTANCEAU (Poitiers, Universite, France), O. DAUBE, and TA PHUOC LOC (CNRS, Laboratoire d'Informatique pour la Mecanique et les Sciences de l'Ingenieur, Orsay, France) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 363-368.

The time formation of the two-dimensional wake induced by an impulsively started thin profile is investigated both experimentally and numerically. The experimental technique is based on a precise visualization of the flow pattern with solid tracers from which quantitative data as well as qualitative information are deduced and used to improve the numerical simulation. This simulation is made by treating the Navier-Stokes equations with a high order compact finite difference scheme. The very good agreement exhibited by the results provided by the two methods makes it possible to give an accurate and detailed description of the evolution of the flow structure for both an elliptic cylinder and a NACA 0012 airfoil. These results are given for angles of attack ranging from 0 to 90 deg and for Reynolds numbers of 500, 1000, and 3000. Author

**A85-47131**

**VORTEX FLOW VISUALIZATION STUDIES OF A STRAKE-WING IN WATER TUNNEL**

B. ZHOU, M. LIU, S. XION, Z. LI, and W. SU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 402-407. refs

Results of water-tunnel tests conducted on a strake-wing and a basic wing using a dye visualization technique are reported. The technique described here is shown to provide three-dimensional flow patterns of the leading edge vortex and its bursting. The results are analogous to those obtained in wind tunnel tests for a strake-wing with a sharp leading edge. The main flow patterns of the moderate sweptback cropped delta wing in the water tunnel tests can also be compared with the results of low-speed wind tunnel tests in the case where the wing leading edge is sharp. V.L.

**A85-47150**

**DETERMINATION OF LEADING-EDGE VORTEX TRAJECTORIES BY SCHLIEREN PHOTOGRAPHY**

J. ER-EL (Technion - Israel Institute of Technology, Haifa, Israel) IN: Flow visualization III; Proceedings of the Third International Symposium, Ann Arbor, MI, September 6-9, 1983 . Washington, DC, Hemisphere Publishing Corp., 1985, p. 676-680. refs

Flow on the leeside of a close-coupled canard-delta wing configuration is studied using the method of schlieren photography. The approach described here makes use of compressibility effects at the vortex core, which are a result of the subpressure generated by the azimuthal velocities, and of the increased axial velocities. These density changes, when sufficient, are detected by a schlieren system whose light rays are perpendicular to the vortex axis, while the knife-edge is parallel to it. Test results illustrating the effect of the canard sweep angle and longitudinal position on the leading-edge vortices and their breakdown characteristics are presented. V.L.

**A85-47258#**

**A STUDY OF THE PHYSICAL MECHANISMS AND THE PERTURBATIONS CREATED BY THE ATTACHMENT OF AN ARC TO A CONDUCTING CYLINDER**

P. LEVESQUE, J. TAILLET, G. LABAUNE, S. LARIGALDIE, and J. C. ALLIOT (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Lightning and Static Electricity, Paris, France, June 10-12, 1985) ONERA, TP, no. 1985-47, 1985, 9 p. DRET-supported research. refs
(ONERA, TP NO. 1985-47)

The typical phenomena related to voltage shock excitation of a suspended cylinder are analyzed in comparison with previous interpretations. The respective role, on the external electric field and on the internal voltage transients, of capacitive currents, streamers, leaders and arc transitions are emphasized. The rationale for voltage shock excitation aircraft testing is deduced from the conclusion of the study. Use of a medium-voltage fast rise-time Marx generator (300 kV, 50 ns) rather than a high voltage slow rise-time one (1.4 MV, 1 micron) is recommended. Author

**A85-47273#**

**AN EXAMINATION OF TURBULENCE MODELS FOR A SEPARATING THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER**

R. ABID, J. DELERY, and R. SCHMITT (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Numerical Methods in Laminar and Turbulent Flows, 4th, University of Wales, Swansea, July 9-12, 1985) ONERA, TP, no. 1985-74, 1985, 13 p. refs
(ONERA, TP NO. 1985-74)

Turbulence modeling in separating 3-D boundary layers using an inverse method is discussed. The ability of models developed for 2-D flows to predict the separation of a 3-D boundary layer is examined, as is the influence of Rotta's (1977) hypothesis that the cause of the disagreement between calculative and experimental prediction of low speed flows with severe crossflow is an inadequate modeling of the pressure-strain correlation term of the Reynolds tensor transport equation. The validity of the considered models is tested by comparison with the well-known experiments of Van den Berg (1972) and Elsenaar (1974), which simulate an infinite swept wing situation. The boundary layer equations are solved by an inverse method with prescribed displacement thicknesses. C.D.

**A85-47288#**

**CERAMIC HEAT EXCHANGERS FOR GAS TURBINES OR TURBOJETS [INTERET DES ECHANGEURS EN CERAMIQUE POUR TURBINE A GAZ OU TURBOREACTEURS]**

S. BOUDIGUES and J. FABRI (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium sur les Echanges Thermiques et Refroidissement dans les Moteurs a Turbines, 65th, Bergen, Norway, May 6-10, 1985) ONERA, TP, no. 1985-35, 1985, 14 p. In French.
(ONERA, TP NO. 1985-35)

The required performance goals and several proposed designs for SiC heat exchangers for aerospace turbines are presented. Ceramic materials are explored as a means for achieving higher operating temperatures while controlling the weight and cost of the heat exchangers. Thermodynamic analyses and model tests by ONERA have demonstrated the efficacy of introducing a recooling cycle and placing the heat exchangers between stages of the turbine. Sample applications are discussed for small general aviation aircraft and subsonic missiles equipped with single-flux exchangers. A double-flux exchanger is considered for an aircraft capable of Mach 0.8 speed and at least 11 km altitude for cruise. Finally, the results of initial attempts to manufacture SiC honeycomb heat exchangers are detailed. M.S.K.

**A85-47380**

### ULTRASONIC DETECTION OF CRACKS IN WEB GEOMETRIES

T. A. GRAY and R. B. THOMPSON (DOE, Ames Laboratory, Ames, IA) IN: Review of progress in quantitative nondestructive evaluation. Volume 3A - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 47-56; Discussion, p. 56. refs
(Contract W-7405-ENG-82)

A computer model is described which numerically simulates the crack detection process in order to identify system configurations which promise a high probability of crack detection. The experimental verification of the model's accuracy is shown using predictions for backscatter from cracks in a 0.635 cm thick diffusion-bonded IN100 plate. The use of the model in the design and optimization of ultrasonic detection systems for cracks in web geometries is illustrated. C.D.

**A85-47381**

### ULTRASONIC MICROSTRUCTURAL NOISE PARAMETERS IN A POWDER METAL ALLOY

B. R. TITTMANN, L. A. AHLBERG, and K. W. FERTIG (Rockwell International Science Center, Thousand Oaks, CA) IN: Review of progress in quantitative nondestructive evaluation. Volume 3A - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 57-63; Discussion, p. 63, 64. refs
(Contract W-7405-ENG-82)

The ultrasonic backscattering characteristics were measured for IN-100, a powder metallurgy alloy used for engine disk components. The data were obtained with a variety of different transducers placed either in a waterbath or in sample contact for a frequency range from 2 to 18 MHz and statistically averaged over numerous volume elements of the samples. Micrographical examination provided size and number distributions for grain and pore structure and showed that the predominant sources for backscatter were the larger micropores. Two samples with different micropore densities were used to demonstrate the feasibility of calculating microstructural parameters from the ultrasonic data. Author

**A85-47396**

### CRACK CHARACTERISATION IN TURBINE DISKS

L. J. BOND and N. SAFFARI (University College, London, England) IN: Review of progress in quantitative nondestructive evaluation. Volume 3A - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 251-260; Discussion, p. 261, 262. Research supported by the Ministry of Defence (Procurement Executive). refs

Nondestructive testing techniques which provide reliable quantitative defect characterization are of considerable importance for a full utilization of fracture mechanics approaches and the application of Retirement-for-Cause (RFC) concepts to critical aerospace components. In the present paper, ultrasonic techniques are presented which have been developed for the detection and characterization of small surface defects in aircraft engine turbine disks. These techniques are based on a utilization of the reflection of surface waves and the phenomena of body-to-surface mode-conversion found at surface breaking and near surface defects for features in the range from 0.05 to 1.0 mm. Possibilities concerning a crack characterization on the basis of the results obtained with the considered techniques are examined, taking into account the midfrequency regime where the defect depth is comparable to or just smaller than the wavelengths involved. G.R.

**A85-47402**

### DEVELOPMENT OF A QUANTITATIVE FLAW CHARACTERIZATION MODULE - A STATUS REPORT

G. J. GRUBER, G. J. HENDRIX, and T. A. MUELLER (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 3A - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 309-320; Discussion, p. 320, 321. refs
(Contract F33615-81-C-5066)

It is pointed out that life-management technology now being developed for the Air Force under the name 'retirement for cause' requires reliable and accurate ultrasonic techniques for characterizing internal bulk flaws in titanium- and nickel-based alloy disk materials. The present paper is concerned with the utilization of quantitative nondestructive evaluation techniques based on the interaction of ultrasound with internal bulk flaws. A flow diagram of the program established to qualify the Born inversion technique for sizing voids and inclusions in typical aircraft turbine-engine parts is considered. Ultrasound-flaw interaction models are discussed, taking into account the Born model for spherical inclusions, and the Franz-Gruber model for spherical voids. An algorithm performance evaluation is also conducted, giving attention to shear-wave measurements, and longitudinal-wave measurements. G.R.

**A85-47428**

### LABORATORY STUDIES RELATED TO IN-FLIGHT ACOUSTIC EMISSION MONITORING

S. R. LAMB (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 729-734.

Laboratory tests undertaken to identify the source of acoustic emission (AE) detected in flight on the MACCHI aircraft are reported, and the results obtained using different equipment are compared. The test component was subjected to repeated application of a spectrum of loads representative of the previous flight history, simulating a sequence of 200 flights. A significant difference in the rates of AE counts with increasing crack length between in-flight tests and laboratory tests is found and discussed. C.D.

**A85-47469**

### MANUFACTURING TECHNOLOGY FOR NONDESTRUCTIVE EVALUATION (NDE) SYSTEM TO IMPLEMENT RETIREMENT FOR CAUSE (RFC) PROCEDURES FOR GAS TURBINE ENGINE COMPONENTS

F. M. TAYLOR, D. L. BIRX, and D. G. DOOLIN (Systems Research Laboratories, Inc., Dayton, OH) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 1331-1335; Discussion, p. 1335-1337.

An automated NDE inspection system capable of detecting 5 x 10 mil surface flaws and 15 mil inclusions in engine rotor components is being developed. This system represents an aid for the implementation of the 'Retirement for Cause' (RFC) philosophy according to which the large percentage of good, used engine rotor components are returned to service, and the small percentage of flawed components are retired for cause. Particular attention is given to the detection and characterization of critical flaws through a utilization of computer algorithms. It is pointed out that the Inspection Module's NDE Instrumentation represents the most advanced computer-controlled ultrasonic and eddy current instrumentation available. G.R.

**A85-47470**

**NDT-33 - A COMPUTERIZED EDDY CURRENT INSTRUMENT**

R. C. BODMER, C. L. FREDERICK, L. L. LANG, and J. J. PICKERD (NORTEC Corp., Kennewick, WA) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 1339-1346; Discussion, p. 1346, 1347.

In connection with the Air Force 'Retirement for Cause' Program, a high-speed computer-controlled multifrequency digital eddy current inspection instrument is being developed for automated aircraft engine disk inspection. The instrument is primarily digital and completely controlled by software for automatic computerized disk inspection. The use of new high-speed microprocessors allows fast scanning and processing of data for an automatic inspection system. The digital signal processing makes the unit versatile for many other inspections using manual or computer operation. Attention is given to a system diagram, system operation, the controller, the display, the oscillator, the detector and converter, the digital signal processor, the proximity probe, and the scanner drive electronics G.R.

**A85-47472**

**INNOVATIVE EDDY CURRENT PROBE COUPLING METHOD**

G. M. LIGHT, W. R. VAN DER VEER, W. D. PERRY, and G. L. BURKHARDT (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 1359-1366; Discussion, p. 1367, 1368.

A design of an air-bearing eddy current probe, for use in the Retirement for Cause/Nondestructive Examination (RFC/NDE) program, to examine aircraft engine parts is presented. The air-bearing acts like a spring which interacts with the probe suspension spring in order to achieve equilibrium at a certain liftoff. The probe is to follow the surface of the suspension, while holding the thickness of the air-film constant, as the total distance from the probe surface to the suspension mount changes. For optimum stability and accuracy the stiffness of the air-bearing must be greater than the stiffness of the suspension; stiffness is determined by the surface area and air flow. The air-bearing eddy current probe was designed and tested for static and dynamic cases. In all cases, the stability of the air-bearing thickness was approximately + or - 0.0001 inch with an average liftoff of 0.0007 inch. I.F.

**A85-47473**

**DEVELOPMENT OF ACTIVE MICROWAVE FERROMAGNETIC RESONANCE EDDY CURRENT PROBES AND ASSOCIATED SIGNAL PROCESSING METHODS**

J. M. PRINCE (Battelle Pacific Northwest Laboratories, Richland, WA) and B. A. AULD (Stanford University, CA) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 1369-1376. (Contract F33615-82-C-5100)

A number of theoretical and experimental studies have been conducted with YIG (Yttrium Iron Garnet)-based FRM (ferromagnetic resonance) eddy current probes. A primary goal of this research was to develop a method of discriminating between liftoff and flaw signals. The present investigation has an additional aim which is related to the development and demonstration of a practical FMR-based flaw detection system for aircraft turbine engine component inspection. In order to overcome certain difficulties, it was decided to utilize the FMR probe in an active mode in which it operates as the resonant element of a microwave oscillator circuit (active FMR probe) at frequencies in the range from 600 to 1100 MHz. The experimental results presented in this paper demonstrate that two-parameter discrimination of flaw data from liftoff noise is realizable with a single active FMR probe and associated processing electronics. G.R.

**A85-47474**

**ELECTRIC CURRENT PERTURBATION INSPECTION OF SELECTED RETIREMENT-FOR-CAUSE TURBINE ENGINE COMPONENTS**

G. L. BURKHARDT, F. N. KUSENBERGER, and R. E. BEISSNER (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 1377-1386; Discussion, p. 1387. USAF-supported research.

The Electric Current Perturbation (ECP) automated inspection system is currently undergoing optimization for the inspection of typical F100 turbofan engine component features, such as antirotation windows and blade slots. A computer-controlled laboratory breadboard ECP system has been fabricated for the scanning of these complex features. While ECP evaluations were initially performed on simple geometry specimens in order to demonstrate the method's sensitivity, preliminary results have recently been obtained on antirotation windows in the F100 engine 2nd-3rd fan stage seal, as well as on blade slots in the first stage fan disk. O.C.

**A85-47475**

**EVALUATION OF CAPTURED WATER COLUMN TECHNOLOGY FOR ADVANCED ULTRASONIC SIZING TECHNIQUES**

G. M. LIGHT, R. A. CERVANTES, and W. R. VAN DER VEER (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 3B - Proceedings of the Tenth Annual Review, Santa Cruz, CA, August 7-12, 1983 . New York, Plenum Press, 1984, p. 1389-1396; Discussion, p. 1397, 1398.

A fighter engine inspection system combining both ultrasonic and eddy current has been developed for the Air Force in connection with the Retirement For Cause/Nondestructive Examination (RFC/NDE) program. The design and testing of several captured water columns in the RFC/NDE system is discussed in comparison with conventional immersion-mode time-amplitude signal measurements and Born inversion techniques. The patented design features of the system include: a water guide to give even distribution of the two inlet water streams; a water focus extension collar to concentrate water flow at the lens of the transducer; and an extension collar to increase the range of focal distances. It is shown that the water column system did not degrade the quality of the reflected ultrasonic pulses in measurements of flaw size range. I.H.

**A85-47849**

**PREDICTION OF THE INCEPTION OF CAVITATION ON BLADE PROFILES OF HYDRAULIC TURBOMACHINES [VORAUSSAGE DES KAVITATIONSBEGINNS AN SCHAUFELPROFILEN HYDRAULISCHER TURBOMASCHINEN]**

J. STELLER (Polska Akademia Nauk, Instytut Maszyn Przeplywowych, Gdansk, Poland) Forschung im Ingenieurwesen (ISSN 0015-7899), vol. 51, July 1985, p. 123-131. In German. refs

A number of methods for the calculation of the velocity distribution on blade profiles have been developed after Scholz (1965) provided his presentation of the aerodynamics of cascades. The computational procedures discussed by Jacob (1963, 1969, 1976, 1981) deserve particular attention. It has also been possible to observe certain relations between cavitation inception and phenomena in the boundary layer. The concepts employed by Jacob are based on the theory of harmonic vector fields and the theoretical results reported by Martensen and von Sengbusch (1960). In the present study an approach is shown for utilizing Jacob's concepts for selected periodic profile configurations. Particular attention is given to the flow through a straight cascade and the flow around a wing located between parallel walls. A suitable FORTRAN program for the calculation of the flow between parallel walls has been developed by Steller (1983). The prediction of cavitation inception is illustrated with the aid of two examples involving NACA foils. G.R.

**A85-48084**
**ACOUSTIC EMISSION MONITORING OF FLAW GROWTH IN A GRAPHITE-EPOXY EXPERIMENTAL WING SEGMENT**
J. RODGERS (Acoustic Emission Technology Corp., Sacramento, CA) Journal of Acoustic Emission (ISSN 0730-0050), vol. 4, January-March 1985, p. 1-8. refs

Acoustic emission (AE) monitoring of flaw growth was performed on a composite wing segment. An 8-channel AE system with a microcomputer to acquire and process AE data was used to monitor a graphite-epoxy upper wing segment during load testing. A tension limit load cycle was conducted; then the wing was loaded in compression to limit load, where it failed after 30 sec by buckling along the inboard flange. At low load levels the AE data revealed damage in the outboard flange. The low felicity ratio signaled the onset of creep instability. The results corresponded well to previous tests. It is concluded that AE monitoring could provide great assistance in early assessment of fiber composite materials. I.F.

**A85-48220**
**COMPUTATIONAL METHODS FOR DISCONTINUITIES IN FLUIDS**
O. A. MCBRYAN (New York University, NY) IN: Large-scale computations in fluid mechanics; Proceedings of the Fifteenth Summer Seminar on Applied Mathematics, La Jolla, CA, June 27-July 8, 1983. Part 2 . Providence, RI, American Mathematical Society, 1985, p. 63-79. refs
(Contract DE-AC02-78ER-03077; NSF DMS-83-12229)

In the present paper, a description is provided of a range of computational methods for fluid flows in which shocks or discontinuities occur. Collectively, these methods constitute the method of front tracking. Front tracking refers to certain computational methods in which special degrees of freedom are placed at fronts or discontinuities in order to obtain increased resolution in those areas. In shock tracking, an extra lower-dimensional grid is introduced, geometrically fitting the shocks. Attention is given to discontinuities in fluid physics, numerical computations, shock tracking methods, current applications of tracking, efficient elliptic solution methods, finite element and discontinuities, high-order solutions by ADI (Alternating Direction Implicit) preconditioning, multigrid solutions, and interfaces and discontinuities. G.R.

**A85-48224**
**SOME CONTRIBUTIONS TO THE MODELLING OF DISCONTINUOUS FLOWS**
P. L. ROE (Royal Aircraft Establishment, Bedford, England) IN: Large-scale computations in fluid mechanics; Proceedings of the Fifteenth Summer Seminar on Applied Mathematics, La Jolla, CA, June 27-July 8, 1983. Part 2 . Providence, RI, American Mathematical Society, 1985, p. 163-193. refs

Roe (1980) advanced the claim that 'almost any' good numerical technique for solving the linear scalar wave equation could be converted, by a fairly simple mechanism, into an equally good numerical technique for solving quasi-linear systems of conservation laws. It is pointed out that the particular attraction of that mechanism lay in its ability to generalize the class of asymmetric, or 'upwinded' finite-difference schemes, in a simple and natural way. In the present investigation, Roe's claim is reviewed and revised in the light of two and a half years of additional experience. A fairly general form of the flux difference splitting concept, applicable to one-dimensional conservation laws, is discussed. Attention is given to the 'monotone' second-order scheme, the designing of the B-functions, and problems regarding satisfying entropy. G.R.

**A85-48521*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**DIGITAL FRINGE REDUCTION TECHNIQUES APPLIED TO THE MEASUREMENT OF THREE-DIMENSIONAL TRANSONIC FLOW FIELDS**
F. BECKER and Y. H. YU (NASA, Ames Research Center, Moffett Field, CA) Optical Engineering (ISSN 0091-3286), vol. 24, May-June 1985, p. 429-434. refs

A system for digital inteferogram evaluation based on an image-processing system connected to a host computer has been implemented. The system supports one- and two-dimensional interferogram evaluations. Interferograms are digitized, enhanced, and segmented. The fringe coordinates are extracted, and the fringes are represented as polygon data structures. Fringe numbering and fringe interpolation modules are implemented. The system supports editing and interactive features as well as graphic visualization. An application of the system to the evaluation of double exposure interferograms from the transonic flow field around a helicopter blade and the reconstruction of the 3-D flow field are given. Author

**A85-48557#**
**THE ROLE OF DAMPING ON SUPERSONIC PANEL FLUTTER**
I. LOTTATI (Technion - Israel Institute of Technology, Haifa) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1640-1642. refs

Attention is given to the effects of viscoelastic damping on the instability of a plate in supersonic flow, including those aspects of damping which involve coupling with midplane forces or external damping. The panel in question is a flat, simply supported one-dimensional beam that is subjected to supersonic flow over one of its sides. O.C.

**A85-48853**
**NEW AWOS PROVIDES SYNTHESIZED-VOICE WEATHER INFORMATION**
A. GREENBERG, J. STERN, and W. HACKENBERG (General Signal Corp., Cardion Electronics Div., Woodbury, NY) ICAO Bulletin, vol. 40, April 1985, p. 16-19.

A complete Automated Weather Observation System (AWOS) that measures wind direction and speed, wind gusts, temperature, dew point, precipitation, visibility, cloud height and cover, altimeter setting, and density altitude is described. AWOS averages the continuously measured weather parameters, converting them into a synthesized-voice output that can modulate a VHF transmitter or navaids voice channel for transmission directly to a pilot in flight. Remote access to the weather message is achieved by a telephone coupler, while a modem allows access to the recorded digital weather data. A newer version of AWOS comprised of four interaction systems, the weather reporting station (data collection and dissemination), two remote sensing facilities, the center-field site and the runway site, and the weather message transmission capability, is also described in detail. I.S.

**A85-48992**
**NUMERICAL SIMULATIONS OF VISCOUS FLUID FLOWS IN AIR INTAKES AT HIGH ANGLES OF ATTACK [SIMULATIONS NUMERIQUES D'ECOULEMENTS DE FLUIDES VISQUEUX DANS LES ENTREES D'AIR A GRANDE INCIDENCE]**
C. BEGUE, B. MANTEL, J. PERIAUX (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France), M. O. BRISTEAU (Institut National de Recherche en Informatique et Automatique, Rocquencourt, France), and R. GLOWINSKI (Paris VI, Universite, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 21st, Ecully, France, Nov. 7-9, 1984. 43 p. In French. refs
(Contract DRET-80-321; DRET-83-403)
(AAAF PAPER NT 84-12)

Techniques are presented for finite element solution of the Navier-Stokes equations (NSE) for steady and unsteady flows of incompressible and compressible viscous fluid flows. A time-step discretization is performed in Hilbert space by means of a decomposition of operators. Two schemes are described for the

decomposition, and applications with the NSE are developed to illustrate methods of separating the incompressibility and nonlinearity of the NSE. The models are extended to the case of compressible fluids, and results are provided from several two- and three-dimensional calculations for the flow into a jet engine intake duct at high angles of attack.
M.S.K.

**A85-49100**

**AEROSPACE RADIOGRAPHY - THE LAST THREE DECADES**

D. J. HAGEMAIER (Douglas Aircraft Co., Long Beach, CA) Materials Evaluation (ISSN 0025-5327), vol. 43, Sept. 1985, p. 1262-1264, 1266, 1268 (12 ff.). refs

The developments in industrial radiography over the period 1955-1985 are reviewed with particular reference to aerospace applications. Topics discussed include: in-motion radiography of weldments; radiography of honeycomb structures, helicopter composite rotor/propeller blades, and solid-propellant rocket motors; and jet engine gamma-ray inspection. The discussion also covers cinefluorography and X-ray image intensifier tests, neutron-radiography of special aerospace components, microfocus radiography, and advanced computer tomography. Finally, the use of advanced industrial X-ray technology in the Space Shuttle project is examined.
V.L.

**A85-49346**

**RADAR TARGETS REVEAL ALL TO AUTOMATED TESTER**

R. E. HARTMAN (Flam and Russell, Inc., Horsham, PA) Microwaves & RF (ISSN 0745-2993), vol. 24, Sept. 1985, p. 101, 102, 104, 106, 107.

Technological developments in the field of automated test equipment for low radar-cross-section (RCS) systems are reviewed. Emphasis is given to an Automated Digital Analysis and Measurement (ADAM) system for measuring, scattering, and evaluating RCS using a minicomputer in combination with a vector network analyzer and a positioner programmer. ADAM incorporates a stepped CW measurement technique to obtain RCS as a function of both range and frequency at a fixed aspect angle. The operating characteristics and calibration procedures of the ADAM system are described and estimates of RCS sensitivity are obtained. The response resolution of the ADAM system is estimated to be 36 cm per measurement bandwidth (in GHz) for a minimum window. A block diagram of the error checking routine of the ADAM system is provided.
I.H.

**A85-49351**

**EFFECTS CAUSED BY SMALL DISCRETE TWO-DIMENSIONAL ROUGHNESS ELEMENTS IMMERSED IN TURBULENT BOUNDARY LAYERS**

H.-H. NIGIM (Birzeit University, Jordan) and D. J. COCKRELL (Leicester, University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 153, April 1985, p. 17-30. refs

In order to determine the downstream consequences of the presence of small discrete surface discontinuities situated on otherwise smooth surfaces and subjected to six equilibrium two-dimensional adverse-pressure-gradient turbulent boundary-layer flows, these conditions were first established in a special purpose wind tunnel. A surface discontinuity is small if it lies within the logarithmic region of the undisturbed boundary layer. Immediately downstream of such discontinuities flow separation ensues. After the subsequent reattachment, measurements were made of the downstream boundary-layer development. Even in strong adverse pressure gradients the local increments of momentum thickness caused by these roughness elements were well predicted by Gaudet and Johnson's (1970) zero-pressure-gradient correlation. With highly adverse pressure gradients it was found that these small surface discontinuities have little influence on the flow downstream. The essential outcome of this work is that the incremental drag of small roughness elements depends solely on local wall variables. Thus, when the pressure gradient is strongly adverse and the local skin friction is correspondingly small, the incremental drag of the roughness element becomes similarly small. After reattachment, it has an insignificant effect on the flow downstream of it.
Author

**A85-49359**

**TEMPERATURE FLUCTUATIONS AND HEAT FLUX IN GRID-GENERATED ISOTROPIC TURBULENCE WITH STREAMWISE AND TRANSVERSE MEAN-TEMPERATURE GRADIENTS**

R. BUDWIG, S. CORRSIN (Johns Hopkins University, Baltimore, MD), and S. TAVOULARIS (Ottawa, University, Canada) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 153, April 1985, p. 441-460. NSF-supported research. refs

A screen of closely spaced, parallel, thin wires was placed downstream of a grid generating nearly isotropic turbulence. The screen was normal to the flow and was heated in one of two modes: (1) periodically in time, to generate a train of transversely uniform streamwise thermal ramps, each with a uniform streamwise gradient, and (2) steadily, with transverse non-uniformity, to generate a uniform transverse thermal ramp. The simple temperature and temperature-gradient fluctuation statistical properties in both cases were found to be comparable to those encountered in earlier works with a steadily heated grid producing a uniform transverse thermal ramp. In both modes of heating the temperature fluctuations decreased initially behind the screen and then increased monotonically. The turbulent heat-transfer correlation coefficient attained an asymptotic magnitude between 0.7 and 0.8 for both modes of heating. The skewness of the temperature fluctuation derivative in the direction of the mean gradient was found to be non-zero despite the absence of mean shear.
Author

**A85-49526**

**ANNUAL RELIABILITY AND MAINTAINABILITY SYMPOSIUM, SAN FRANCISCO, CA, JANUARY 24-26, 1984, PROCEEDINGS**

Symposium sponsored by IEEE, AIAA, ASME, et al. New York, IEEE, 1984, 576 p. For individual items see A85-49527 to A85-49589.

The present conference addresses topics in computer-aided reliability and maintainability, mechanical reliability, the management of reliability and maintainability (R&M), the status of the U.S. Department of Defense/industry R&M study, reliability assessment, testing, and screening, testability and automatic testing, dormant reliability, the use of R&M field data, software reliability, built-in testing (BIT), modeling and simulation methods, robotics and automation, operational readiness, reliability growth, and maintainability. Specific attention is given to electronic equipment thermal management, MTBF predictions, BIT self-verification, expert systems in software maintainability, spacecraft anomalies and lifetimes, fiber-optics reliability, and lower limits for total ship reliability.
O.C.

**A85-49530#**

**ELECTRONIC EQUIPMENT THERMAL MANAGEMENT**

R. L. BERGER and L. C. JENKINS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 17-22.

An assessment is made of the importance of thermal management in electronic equipment design, illustrating the ways in which CAD technology may be used to improve electronic equipment thermal management programs. Attention is given to the Electronic Equipment Thermal Management portion of the aircraft system-level Thermal Management Control (TMC) program. TMC establishes the process by which the airframe's environmental control system and the electronic equipment are integrated to optimize system reliability through life cycle cost minimization, by allocating available cooling capacity to system elements on the basis of derived benefits.
O.C.

**A85-49536**

**MAINTAINABILITY ASPECTS IN MAINTENANCE MANAGEMENT**

W. R. DOWNS (Wm. Downs Technical/Management Services, Rancho Palos Verdes, CA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 62-66. refs

This paper discusses the need for the operator of equipment to continue the efforts of the manufacturer in the user environment in order to assure the maintainability performance potential built into the system. The maintainability performance predicted for the system is usually based on an operations model that is assumed to be real but may differ in many ways from the actual operations environment. Downtime, availability, and maintenance manhours, the common maintainability performance criteria, can vary widely as a function of maintenance concepts and maintenance planning to control those elements that are crucial to the attainment of maintainability performance objectives. Data relating to operations are presented in regard to the maintainability performance parameters they affect, and analyses are presented as examples of the types of analyses system operators may perform in order to optimize maintainability performance in the field. Author

**A85-49538**

**DOD/INDUSTRY - R&M TECHNOLOGY STUDY ANALYSIS**

H. B. LYON, JR. (Texas Instruments, Inc., Arlington, VA) and K. P. LASALA (U.S. Navy, Naval Material Command, Arlington, VA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 99-102.

Attention is given to the Technology Study portion of the Institute for Defense Analyses' Reliability and Maintainability (R&M) study, which focused on processes for the derivation of technology requirements, the identification of 'ripple effects' associated with novel technologies' introduction and mutual interaction, and an approach to the 'off-line' maturation of technologies. The R&M study has uniquely constituted a comprehensive joint government/industry review of important emerging technologies. O.C.

**A85-49539#**

**ESTABLISHING REALISTIC REQUIREMENTS FOR RELIABILITY, MAINTAINABILITY, AND BUILT-IN-TEST**

R. C. TRAKAS (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 103-107.

Steps have been taken within the Naval Air Systems Command to provide a repeatable, logical approach to establishing realistic requirements for reliability, maintainability, and built-in-test (BIT). This approach prevents problems on programs under development where failure to meet specified requirements in the areas of reliability, maintainability, and BIT could be attributed to establishment of arbitrary, unrealistic requirements with little or no basis in fact. The approach taken ensures the proper relationship between the program thresholds within the Navy and the contractually specified requirements. This provides for a cost-effective and realistic method for ensuring that adequate inherent reliability, maintainability, and BIT capabilities are designed into the equipment to meet the stated operational requirements. Author

**A85-49541**

**A MANAGEMENT GUIDE TO RELIABILITY PREDICTIONS**

F. A. STOVALL (Lockheed-Georgia Co., Marietta, GA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 114-116.

Although reasonably accurate reliability predictions are obtainable through the procedure contained in military standard MIL-HDBK-217, if enough is known about operational environment, equipment design, vendor manufacturing capability, and delivery schedule, a less costly procedure may sometimes be required for the assessment of vendor-claimed reliability levels or the estimation of probable equipment reliability level. Attention is presently given to a simplified prediction chart which, while not as accurate as MIL-HDBK-217, may nevertheless be useful in the preliminary determination pf probable need for part screening, thermal imaging, reliability growth tests, etc. O.C.

**A85-49581**

**AN M PRINCIPLE - PAY ME NOW OR SPEND MORE LATER**

W. B. DALRYMPLE (Boeing Aerospace Co., Seattle, WA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 493-498. refs

The basic principles of a good maintainability (M) program are presented with reference to the reduction of aircraft and aircraft weapons system development costs. Common boundaries between M and interfacing functions are discussed. Particular attention is given to fault isolation, mathematical modeling, maintenance manhours improvements, and mockups. It is concluded that integration is the key element in keeping the cost of M reasonable. B.J.

**A85-49586**

**A SYSTEMATIC APPROACH TO DESIGNING FOR TESTABILITY**

R. JAGER (Westinghouse Electric Corp., Baltimore, MD) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 520-524.

The purpose of this paper is to describe a systematic, formalized, and timely approach to designing avionics for testability at all maintenance levels, which will reduce many of the current problems in the field, such as 'RETEST OKs' and 'CANNOT DUPLICATEs'. The approach was developed to be used by avionics designers, and is recommended for program office personnel who specify requirements for avionics design. It was developed to provide a high level of testability to meet specified standards and to maximize the compatibility of the avionics with its support equipment. The objective of this approach to testability in design is to maximize the availability of the avionics system and minimize repair time, spares, and logistics support requirements. Key features of this paper are the systematic approach to designing for all maintenance levels and an integrated maintenance concept which will allow compatible system support, even if separate contractors perform the support at different maintenance levels. Author

**A85-49588**

**R&M ANALYSIS TECHNIQUES FOR FAULT-TOLERANT SYSTEMS**

M. H. VEATCH, A. B. CALVO (Analytic Sciences Corp., Reading, MA), and J. L. MCMANUS (USAF, Logistics and Human Factors Div., Wright-Patterson AFB, OH) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 530-536. refs

Reliability and logistics support analysis techniques for fault-tolerant avionics systems are presented. The systems considered contain integration and dynamic reconfigurability as part of their fault-tolerant design. These characteristics, combined with the need for analysis during the early stages of development, pose unique modeling requirements. The techniques developed address this need by providing design criteria based on reliability and maintainability during the early stages of design. They are applicable to the Integrated Communication, Navigation and Identification Avionics (ICNIA) architectures which are currently entering the advanced development phase. Author

**A85-49704#**

**VARIATIONAL PRINCIPLE FOR TWO DIMENSIONAL FLOWS OF THE COMPRESSIBLE IDEAL FLUID WITH INCONTINUOUS SURFACES**

M. SU (Qinghua University, Beijing, People's Republic of China) Acta Aerodynamica Sinica, no. 3, 1985, p. 34-44. In Chinese, with abstract in English. refs

**A85-50063#**
**BONDED REPAIR OF DAMAGE**
R. JONES (Defence Science and Technology Organization, Aeronautical Research Laboratories, Melbourne, Australia) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 36, Aug. 1984, p. 193-201. refs

Two approaches developed for the analysis and design of repairs of damaged metallic structures by use of fiber-reinforced patches are presented. The finite element approach, discussed along with the formulation of the finite element and derivation of the element stiffness matrix, is illustrated by considering the repair of cracks in the lower wing skin of a Mirage III aircraft. An analytical approach is used in the repair design of a center-notched thin sheet, and is presented along with an approximate closed-form solution. The structural design considerations are emphasized and are illustrated by considering the design of several recent aircraft repair schemes. I.S.

**A85-50065#**
**RECENT ADVANCES IN FATIGUE CRACK GROWTH PREDICTIONS**
G. MARCI (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 36, Aug. 1984, p. 237-254. refs

The capability of accurate fatigue crack growth (FCG) life prediction is essential for optimizing the structural safety and economic operation of modern aircraft. FCG prediction schemes which compute the crack growth rate cycle by cycle and are based on the effective stress intensity concept of Elber (1971) are examined. The basic FCG-rate equations relevant to the Elber model are reviewed, and it is shown that the relatively simple exponential FCG-rate equations have to be modified to accommodate the observed FCG behavior. Procedures for determining the stress intensity factor at which a fatigue crack opens are then discussed. as are some characteristics of the crack growth behavior implied by Newman's approach (1981). It is pointed out that more experimental work is required to refine the modeling of compressive loading in fatigue. V.L.

**A85-50108**
**MANUFACTURE OF COMPOSITE PROPELLER BLADES FOR COMMUTER AIRCRAFT**
R. MCCARTHY (Dowty Rotol, Ltd., Gloucester, England) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 11 p.
(SAE PAPER 850875)

A manufacturing method employing a resin injection process which yields good fiber volume fractions, and correspondingly high structural strength, has been developed for the composite propeller blades that will be used by next-generation turboprop commuter aircraft. NDT and quality control methods are incorporated into this manufacturing process to ensure high quality, as corroborated by a certification procedure for propellers of this new type that encompassed both structural and environmental stresses. The environmental tests include lightning strike and bird strike effects. Flight testing has been conducted with Saab-Fairchild 340, Cheyenne IV, and Fokker 50 twin turboprop aircraft. O.C.

**A85-50113**
**AGE FORMING TECHNOLOGY EXPANDED IN AN AUTOCLAVE**
D. M. HAMBRICK (Avco Corp., Avco Aerostructure Div., Nashville, TN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 18 p.
(SAE PAPER 850885)

Development of the autoclave forming aluminum (AFA) process has advanced current technology of age forming. Using an autoclave for application of aging heat and forming pressure, the process has been used to form 50 feet long, 2124 and 2419 aluminum wing skins containing integrally machined stiffeners and varying in thickness from 0.1 to 2.5 inches with thick pads in the middle of thin sections. The process produces smooth contours with no visible evidence of abrupt changes in thickness. The skins are believed to be the largest and most complex parts ever to be age creep formed in the history of the aircraft industry. Author

**N85-34312#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
**SOME PROBLEMS IN HIGH SPEED GEARS AND GEARING**
J. H. WEBB *In its* Proc. of the Mech. Conf., Vol. 1 10 p 1984 refs 2 Vol.
Avail: NTIS HC A07/MF A01

Some of the causes of noise in high speed gears are considered. Analytical approaches aimed at the prediction and reduction of noise levels, and work conducted on these matters are discussed. Much of the work is taken from helicopter research, however the methods described are relevant to the process and other industries. E.A.K.

**N85-34326#** Department of Energy, Washington, D. C.
**COMBINED COLD COMPRESSOR/EJECTOR HELIUM REFRIGERATOR Patent Application**
D. P. BROWN, inventor (to DOE) 5 Jun. 1984 18 p
(Contract DE-AC02-76CH-00016)
(DE85-006408; US-PATENT-APPL-SN-617656) Avail: NTIS HC A02/MF A01

A refrigeration apparatus having an ejector operatively connected with a cold compressor to form a two stage pumping system is described. This pumping system is used to lower the pressure, and thereby the temperature of a bath of boiling refrigerant (helium). The apparatus as thus arranged and operated has substantially improved operating efficiency when compared to other processes or arrangements for achieving a similar low pressure. DOE

**N85-34354*#** Syracuse Univ., N. Y. Dept. of Mechanical and Aerospace Engineering.
**UNSTEADY TRANSONIC HEAT TRANSFER IN A TRANSIENT FACILITY Semiannual Progress Report**
J. E. LAGRAFF 1 Sep. 1985 8 p
(Contract NAG3-621)
(NASA-CR-176145; NAS 1.26:176145) Avail: NTIS HC A02/MF A01 CSCL 20D

A facility for making heat transfer measurements on solid surfaces using transient techniques is constructed. The facility being constructed is a Ludweig tube with isentropic compression heating (LICH tube). The work completed is detailed as is the work remaining in order to complete the facility and make useful heat transfer measurements. The scope of the project is briefly discussed along with an overall appraisal of the progress. Author

**N85-34355*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**NOZZLE WALL ROUGHNESS EFFECTS ON FREE-STREAM NOISE AND TRANSITION IN THE PILOT LOW-DISTURBANCE TUNNEL**
T. R. CREEL, JR., I. E. BECKWITH, and F. J. CHEN (High Technology Corp.) Sep. 1985 34 p refs Original contains color illustrations
(NASA-TM-86389; L-15903; NAS 1.15:86389) Avail: NTIS HC A03/MF A01 CSCL 20D

An investigation at Mach 3.5 into the effects of nozzle wall roughness on free stream pressure fluctuations and cone transition Reynolds numbers was conducted in the pilot low disturbance tunnel at the Langley Research Center. Nozzle wall roughness caused by either particle deposits or imperfections in surface finish increased free stream noise levels and reduced the transition Reynolds numbers on a cone mounted in the test rhombus. Author

**N85-34378*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**PRACTICAL ASPECTS OF LASER HOLOGRAPHIC INTERFEROMETRY IN WIND TUNNELS**

J. LICURSI and G. LEE Sep. 1985 13 p refs

(NASA-TM-86788; REPT-85365; NAS 1.15:86788) Avail: NTIS HC A02/MF A01 CSCL 14B

Practical aspects of using laser holographic interferometry in some NASA Ames wind tunnels are presented. These aspects include the development of techniques for dual-plate interferometry, optics alignment, and laser alignment. In addition, methods to alleviate problems associated with vibration, photographic processing, photographic drying, and photographic reconstruction are discussed. Author

**N85-34402*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**OXIDIZING SEAL FOR A TURBINE TIP GAS PATH Patent**

J. D. CAWLEY, inventor (to NASA) 10 Sep. 1985 7 p Filed 19 Apr. 1984 Supersedes N84-22935 (22 - 13, p 1993)

(NASA-CASE-LEW-14053-1; US-PATENT-4,540,336; US-PATENT-APPL-SN-602050; US-PATENT-CLASS-415-174; US-PATENT-CLASS-415-170-R; US-PATENT-CLASS-415-196; US-PATENT-CLASS-415-200; US-PATENT-CLASS-416-174)

Avail: US Patent and Trademark Office CSCL 11A

The sealing of the gas path in a gas turbine engine at the blade tips is improved by maintaining a minimum clearance between the rotor blade tips and the gas path seal. This is accomplished by taking advantage of an increase in volume during controlled oxidation of certain intermetallic compounds which have high melting points. The increase in volume closes the clearance subsequent to a rub between the blades and the seal. Thus, these compounds re-form the tip seal surface to assure continued engine efficiency.

Official Gazette of the U.S. Patent and Trademark Office

**N85-34421#** Rolls-Royce Ltd., Derby (England). Product Assurance Supply Group.

**TOWARDS THE YEAR 2000: DEVELOPMENTS IN INSPECTION AND PRODUCT ASSURANCE TO BE ANTICIPATED DURING THE NEXT 15 YEARS**

T. BROUGHTON and A. J. S. PRATT 7 Feb. 1985 8 p

Proposed for presentation at Assoc. Aeron. et Astronautique de France and Assoc. Franc. pour le Controle et la Qualite

(PNR-90258) Avail: NTIS HC A02/MF A01

Trends in aircraft engine inspection technology, including dimensional inspection; visual inspection; and nondestructive testing, including ultrasonics, X-rays, surface integrity, and functional testing are discussed. The role of the computer, and the Rolls-Royce product assurance philosophy are outlined.

Author (ESA)

**N85-35365** Arizona State Univ., Tempe.

**HEAT TRANSFER CHARACTERISTICS FOR TWO-DIMENSIONAL ARRAYS OF IMPINGING JETS WITH INITIAL CROSSFLOW Ph.D. Thesis**

C. C. J. SU 1984 252 p

Avail: Univ. Microfilms Order No. DA8501324

Two-dimensional arrays of circular air jets impinging on a heat transfer surface parallel to the jet orifice plate are considered. The jet flow, after impingement, is constrained to exit in a single direction along the channel formed by the jet orifice plate and heat transfer surface. In addition to the crossflow that originates from the jets following impingement, an initial crossflow is present that approaches the array through an upstream extension of the channel. The configurations considered are intended to model the impingement cooled midchord region of gas turbine airfoils in cases where an initial crossflow is also present. Spanwise averaged heat fluxes, resolved in the streamwise direction to one streamwise jet hole spacing, referred to as regional average fluxes, were measured for twelve arrays each having a different combination of geometric parameter values (streamwise hole spacing, spanwise hole spacing, and channel height each measured relative to jet hole diameter). Measurements were made over a range of jet flow rates and also for a range of initial crossflow rates relative to jet flow rate.

Dissert. Abstr.

**N85-35372*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**COMPUTATION OF THREE-DIMENSIONAL SHOCK WAVE AND BOUNDARY-LAYER INTERACTIONS**

C. M. HUNG Aug. 1985 15 p refs

(NASA-TM-86780; NAS 1.15:86780; REPT-85350) Avail: NTIS HC A02/MF A01 CSCL 20D

Computations of the impingement of an oblique shock wave on a cylinder and a supersonic flow past a blunt fin mounted on a plate are used to study three dimensional shock wave and boundary layer interaction. In the impingement case, the problem of imposing a planar impinging shock as an outer boundary condition is discussed and the details of particle traces in windward and leeward symmetry planes and near the body surface are presented. In the blunt fin case, differences between two dimensional and three dimensional separation are discussed, and the existence of an unique high speed, low pressure region under the separated spiral vortex core is demonstrated. The accessibility of three dimensional separation is discussed. E.A.K.

**N85-35373*#** Imperial Coll. of Science and Technology, London (England).

**VORTEX BOUNDARY-LAYER INTERACTIONS Semiannual Status Report, 1 Mar. - 31 Aug. 1985**

P. BRADSHAW 31 Aug. 1985 15 p

(Contract NAGW-581)

(NASA-CR-176192; NAS 1.26:176192) Avail: NTIS HC A02/MF A01 CSCL 20D

The interaction of a turbulent boundary layer on a flat plate with a strong artificially generated longitudinal vortex which may or may not actually enter the boundary layer is studied. The vortices are generated by a delta wing suspended ahead of the test plate so that the configuration is approximately that of a close coupled carnard with zero main-wing sweep and an invisible body. All necessary configuration and parametric checks are completed, and data acquisition and analysis on the first configuration chosen for detailed study, in which the vortex starts to merge with the boundary layer a short distance downstream of the leading edge of the test plate, are nearly complete. Author

**N85-35391*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.

**DEVELOPMENT OF ADVANCED HIGH-TEMPERATURE HEAT FLUX SENSORS. PHASE 2: VERIFICATION TESTING Final Report**

W. H. ATKINSON, M. A. CYR, and R. R. STRANGE Aug. 1985 69 p refs

(Contract NAS3-22133)

(NASA-CR-174973; NAS 1.26:174973; PWA-5914-39) Avail: NTIS HC A04/MF A01 CSCL 14B

A two-phase program is conducted to develop heat flux sensors capable of making heat flux measurements throughout the hot section of gas turbine engines. In Phase 1, three types of heat flux sensors are selected; embedded thermocouple, laminated, and Gardon gauge sensors. A demonstration of the ability of these sensors to operate in an actual engine environment is reported. A segmented liner of each of two combustors being used in the Broad Specification Fuels Combustor program is instrumented with the three types of heat flux sensors then tested in a high pressure combustor rig. Radiometer probes are also used to measure the radiant heat loads to more fully characterize the combustor environment. Test results show the heat flux sensors to be in good agreement with radiometer probes and the predicted data trends. In general, heat flux sensors have strong potential for use in combustor development programs. Author

**N85-35423*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.

**STUDY OF NSI AND RELATED CABLE PERFORMANCE DURING TESTS PERFORMED IN THE NASA HOT GAS FACILITY**

Z. S. KARU Jan. 1982 32 p
(Contract NAS8-32952)
(NASA-CR-170886; NAS 1.26:170886; LMSC-HREC-TM-D784644)
Avail: NTIS HC A03/MF A01 CSCL 20K

Some seven different configurations of the NSI and other cables were tested in the NASA-MSFC Hot Gas Facility (HGF). The tests were conducted to study what happens to the cables when they are exposed to hot flow as was the case in the first two Shuttle flights, the STS-1 and STS-2. Protection of these components is vital for various functions especially to attain proper nozzle separation. The tests in the HGF demonstrated the severity of the aerodynamic forces combined with aero heating environment on the test cables and helped, in general, to evaluate the cable wrap materials and cable mounting hardware and technique. Blastape 2 cable wrap which is adequate for thermal protection of the cables must be properly clamped at its ends. The nylon clamps (or ties) used to secure cables to metal components inside the skirt could not withstand the heating. K5NA closeout material used on the outboard surface of the aft skirt when troweled over the cables performed excellently in protecting the cables and mounting hardware.

Author

**N85-35425#** Airtech Precision Shot Peening, Livonia, Mich.

**DEVELOPMENT OF A MATHEMATICAL MODEL FOR PREDICTING THE PERCENTAGE FATIGUE LIFE INCREASE RESULTING FROM SHOT PEENED COMPONENTS Final Report, Sep. 1983 - Apr. 1984**

R. S. SIMPSON Wright-Patterson AFB, Ohio AFWAL Apr. 1985 47 p
(Contract F33615-83-C-3252)
(AD-A155774; AFWAL-TR-84-3116) Avail: NTIS HC A03/MF A01 CSCL 12A

Shot peening is used extensively in many aircraft structural and engine applications to enhance fatigue life and stress corrosion resistance. Recent research indicates that high shot peening intensities can produce a phenomenon called peened surface extrusion folds (PSEF) which is hypothesized to result in fatigue life reductions. In this investigation more than one hundred specimens of 7075-T6 and 7075-T73 aluminum material were manufactured and treated at various levels of shot peening intensity, almen saturation level, and peening media size. Specimens were subsequently fatigue tested under axial loading conditions. The longest fatigue life was obtained at relatively low almen intensities with the smallest size glass bead at 100 to 110% almen saturation. Intensity vs fatigue life patterns were similar for both materials. The optimum intensity level was substantially below that specified in MIL-STD-852. Scanning electron microscopy and metallography showed increasing depth and quantity of PSEF and embedded glass bead particles at the surface as peening intensity increased. Test work demonstrated statistically significant effects of PSEF, embedded glass particles, percent of almen saturation, part material hardness, and peening media size on specimen fatigue life. Multiple linear statistical regression of these four variables accounted for a high percentage of the variance in specimen fatigue life.

Author (GRA)

**N85-35556#** Technische Univ., Munich (West Germany). Lehrstuhl fuer Flugmechanik und Flugregelung.

**DEVELOPMENT AND OPERATION OF A MEASURING DATA ACQUISITION SYSTEM FOR USE IN LIGHT AIRPLANES [ENTWICKLUNG UND BETRIEB EINER MESSDATENERFASSUNGSANLAGE (MEA) FUER DEN EINSATZ IN LEICHTFLUGZEUGEN]**

P. HUBER *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 157-160 Jan. 1985 In GERMAN
Avail: NTIS HC A10/MF A01

A data acquisition system weighing 35 kg is developed for use onboard light aircraft. The basic concept of the system (task definition, requirements) is given. Development status (onboard components, special systems, ground components, measuring data recorder, technical data, and data evaluation software) is presented. The performed measurements are reviewed.

Author (ESA)

## 13

## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A85-47264#**

**IN-FLIGHT ELECTRICAL CONDUCTIVITY MEASUREMENTS**

P. GONDOT and A. DELANNOY (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Lightning and Static Electricity, Paris, France, June 10-12, 1985) ONERA, TP, no. 1985-61, 1985, 6 p. DRET-supported research. refs
(ONERA, TP NO. 1985-61)

Convective cloud electrical behavior is related to such global parameters as the atmospheric electric field, and to such local phenomena as the electrical charge of drops and droplets and their ionic conductivity. ONERA has conducted cloud conductivity sensor development efforts based on the Gerdien design, and deployed such sensors aboard a Transall aircraft during a thundercloud and lightning flash study campaign in southwestern France held in the spring of 1984. The three different sensors used were respectively distinguished by (1) automatic bias for conductivity, ionic density, and mobility measurements, (2) high voltage bias with a multireceiver electrode for fast analysis of cloud transition zones, and (3) adjustable bipolar high voltage bias.

O.C.

**N85-34444*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**REFLECTION PLANE TESTS OF A WIND TURBINE BLADE TIP SECTION WITH AILERONS Final Report**

J. M. SAVINO, T. W. NYLAND, A. G. BIRCHENOUGH, F. L. JORDAN (NASA, Langley Research Center), and N. K. CAMPBELL (NASA, Langley Research Center) Aug. 1985 57 p refs
(Contract DE-AI01-79ET-20320)
(NASA-TM-87018; E-2564; DOE/NASA/20320-65; NAS 1.15:87018) Avail: NTIS HC A04/MF A01 CSCL 10A

Tests were conducted in the NASA Langley 30 by 60 foot Wind Tunnel on a full scale 7.31 m (24 ft) long tip section of a wind turbine rotor blade. The blade tip section was built with ailerons on the trailing edge. The ailerons, which spanned a length of 6.1 m (20 ft), were designed so that two types could be evaluated: the plain and the balanced. The ailerons were hinged on the suction surface at the 0.62 X chord station behind the leading edge. The purpose of the tests was to measure the aerodynamic characteristics of the blade section for: an angle of attack range from 0 deg to 90 deg aileron deflections from 0 deg to -90 deg, and Reynolds numbers of 0.79 and 1.5 x 10 to the 6th power. These data were then used to determine which aileron configuration had the most desirable rotor control and aerodynamic braking characteristics. Tests were also run to determine the effects of vortex generators, leading edge roughness, and the gaps between the aileron sections on the lift, drag, and chordwise force coefficients of the blade tip section.

Author

**N85-35534*#** PRC Planning and Economics, Inc., Lake Success, N.Y.

**COMPARATIVE ANALYSIS OF OPERATIONAL FORECASTS VERSUS ACTUAL WEATHER CONDITIONS IN AIRLINE FLIGHT PLANNING, VOLUME 1**

J. F. KEITZ Apr. 1982 83 p 5 Vol.
(Contract NAS3-22748)
(NASA-CR-167862; NAS 1.26:167862) Avail: NTIS HC A05/MF A01 CSCL 04B

The impact of more timely and accurate weather data on airline flight planning with the emphasis on fuel savings is studied. This volume of the report discusses the results of Task 1 of the four major tasks included in the study. Task 1 compares flight plans based on forecasts with plans based on the verifying analysis from 33 days during the summer and fall of 1979. The comparisons show that: (1) potential fuel savings conservatively estimated to be between 1.2 and 2.5 percent could result from using more timely and accurate weather data in flight planning and route selection; (2) the Suitland forecast generally underestimates wind speeds; and (3) the track selection methodology of many airlines operating on the North Atlantic may not be optimum resulting in their selecting other than the optimum North Atlantic Organized Track about 50 percent of the time. Author

**N85-35535*#** PRC Planning and Economics, Inc., Lake Success, N.Y.

**COMPARATIVE ANALYSIS OF OPERATIONAL FORECASTS VERSUS ACTUAL WEATHER CONDITIONS IN AIRLINE FLIGHT PLANNING, VOLUME 2**

J. F. KEITZ Apr. 1982 54 p 5 Vol.
(Contract NAS3-22748)
(NASA-CR-167863; NAS 1.26:167863) Avail: NTIS HC A04/MF A01 CSCL 04B

The impact of more timely and accurate weather data on airline flight planning with the emphasis on fuel savings is studied. This volume of the report discusses the results of Task 2 of the four major tasks included in the study. Task 2 compares various catagories of flight plans and flight tracking data produced by a simulation system developed for the Federal Aviation Administrations by SRI International. (Flight tracking data simulate actual flight tracks of all aircraft operating at a given time and provide for rerouting of flights as necessary to resolve traffic conflicts.) The comparisons of flight plans on the forecast to flight plans on the verifying analysis confirm Task 1 findings that wind speeds are generally underestimated. Comparisons involving flight tracking data indicate that actual fuel burn is always higher than planned, in either direction, and even when the same weather data set is used. Since the flight tracking model output results in more diversions than is known to be the case, it was concluded that there is an error in the flight tracking algorithm. Author

**N85-35536*#** PRC Planning and Economics, Inc., Lake Success, N.Y.

**COMPARATIVE ANALYSIS OF OPERATIONAL FORECASTS VERSUS ACTUAL WEATHER CONDITIONS IN AIRLINE FLIGHT PLANNING, VOLUME 3**

J. F. KEITZ Apr. 1982 96 p 5 Vol.
(Contract NAS3-22748)
(NASA-CR-167864; NAS 1.26:167864) Avail: NTIS HC A05/MF A01 CSCL 04B

The impact of more timely and accurate weather data on airline flight planning with the emphasis on fuel savings is studied. This volume of the report discusses the results of Task 3 of the four major tasks included in the study. Task 3 compares flight plans developed on the Suitland forecast with actual data observed by the aircraft (and averaged over 10 degree segments). The results show that the average difference between the forecast and observed wind speed is 9 kts. without considering direction, and the average difference in the component of the forecast wind parallel to the direction of the observed wind is 13 kts. - both indicating that the Suitland forecast underestimates the wind speeds. The Root Mean Square (RMS) vector error is 30.1 kts. The average absolute difference in direction between the forecast and observed wind is 26 degrees and the temperature difference is 3 degree Centigrade. These results indicate that the forecast model as well as the verifying analysis used to develop comparison flight plans in Tasks 1 and 2 is a limiting factor and that the average potential fuel savings or penalty are up to 3.6 percent depending on the direction of flight. Author

**N85-35537*#** PRC Planning and Economics, Inc., Lake Success, N.Y.

**COMPARATIVE ANALYSIS OF OPERATIONAL FORECASTS VERSUS ACTUAL WEATHER CONDITIONS IN AIRLINE FLIGHT PLANNING, VOLUME 4**

J. F. KEITZ Apr. 1982 93 p 5 Vol.
(Contract NAS3-22748)
(NASA-CR-167865; NAS 1.26:167865) Avail: NTIS HC A05/MF A01 CSCL 04B

The impact of more timely and accurate weather data on airline flight planning with the emphasis on fuel savings is studied. This volume of the report discusses the results of Task 4 of the four major tasks included in the study. Task 4 uses flight plan segment wind and temperature differences as indicators of dates and geographic areas for which significant forecast errors may have occurred. An in-depth analysis is then conducted for the days identified. The analysis show that significant errors occur in the operational forecast on 15 of the 33 arbitrarily selected days included in the study. Wind speeds in an area of maximum winds are underestimated by at least 20 to 25 kts. on 14 of these days. The analysis also show that there is a tendency to repeat the same forecast errors from prog to prog. Also, some perceived forecast errors from the flight plan comparisons could not be verified by visual inspection of the corresponding National Meteorological Center forecast and analyses charts, and it is likely that they are the result of weather data interpolation techniques or some other data processing procedure in the airlines' flight planning systems. Author

**N85-35538*#** PRC Planning and Economics, Inc., Lake Success, N.Y.

**COMPARATIVE ANALYSIS OF OPERATIONAL FORECASTS VERSUS ACTUAL WEATHER CONDITIONS IN AIRLINE FLIGHT PLANNING: SUMMARY REPORT**

J. F. KEITZ Apr. 1982 47 p 5 Vol.
(Contract NAS3-22748)
(NASA-CR-167866; NAS 1.26:167866) Avail: NTIS HC A03/MF A01 CSCL 04B

The impact of more timely and accurate weather data on airline flight planning with the emphasis on fuel savings is studied. This summary report discusses the results of each of the four major tasks of the study. Task 1 compared airline flight plans based on operational forecasts to plans based on the verifying analyses and found that average fuel savings of 1.2 to 2.5 percent are possible with improved forecasts. Task 2 consisted of similar comparisons but used a model developed for the FAA by SRI International that simulated the impact of ATC diversions on the flight plans. While parts of Task 2 confirm the Task 1 findings, inconsistency with other data and the known impact of ATC suggests that other Task 2 findings are the result of errors in the model. Task 3 compares segment weather data from operational flight plans with the weather actually observed by the aircraft and finds the average error could result in fuel burn penalties (or savings) of up to 3.6 percent for the average 8747 flight. In Task 4 an in-depth analysis of the weather forecast for the 33 days included in the study finds that significant errors exist on 15 days. Wind speeds in the area of maximum winds are underestimated by 20 to 50 kts., a finding confirmed in the other three tasks. Author

**N85-35539*#** University Corp. for Atmospheric Research, Boulder, Colo.

**A PRELIMINARY INTERCOMPARISON BETWEEN NUMERICAL UPPER WIND FORECASTS AND RESEARCH AIRCRAFT MEASUREMENTS OF JET STREAMS**

M. A. SHAPIRO 15 Apr. 1982 10 p Sponsored by NASA
(NASA-CR-167884; NAS 1.26:167884) Avail: NTIS HC A02/MF A01 CSCL 04B

During the past several years, research on the structure of extra-tropical jet streams has been carried out with direct measurements with instrumented research aircraft from the National Center for Atmospheric Research (NCAR). These measurements have been used to describe the wind, temperature, turbulence and chemical characteristics of jet streams. A fundamental question is one of assessing the potential value of existing operational numerical forecast models for forecasting the meteorological conditions along commercial aviation flight routes so as to execute Minimum Flight Time tracks and thus obtain the maximum efficiency in aviation fuel consumption. As an initial attempt at resolving this question, the 12 hour forecast output from two models was expressed in terms of a common output format to ease their intercomparison. The chosen models were: (1) the Fine-Mesh Spectral hemispheric and (2) the Limited Area Fine Mesh (LFM) model. Author

**N85-35540*#** Dayton Univ., Ohio. Research Inst.

**THE PHYSICAL AND EMPIRICAL BASIS FOR A SPECIFIC CLEAR-AIR TURBULENCE RISK INDEX Final Report**

J. L. KELLER Aug. 1985 47 p refs
(Contract NAS8-34678)
(NASA-CR-178522; NAS 1.26:178522; UDR-TR-85-94) Avail: NTIS HC A03/MF A01 CSCL 04B

An improved operational CAT detection and forecasting technique is developed and detailed. This technique is the specific clear air turbulence risk (SCATR) index. This index shows some promising results. The improvements seen using hand analyzed data, as a result of the more realistic representation of the vertical shear of the horizontal wind, are also realized in the data analysis used in the PROFS/CWP application. The SCATR index should improve as database enhancements such as profiler and VAS satellite data, which increase the resolution in space and time, are brought into even more sophisticated objective analysis schemes. E.R.

**N85-35542#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.

**PROCEEDINGS OF METEOROLOGICAL MOTOR GLIDER (MEMO) WORKSHOP '84**

Jan. 1985 213 p refs Partly in ENGLISH and GERMAN Proc. held at Oberpfaffenhofen, West Ger., 1-5 Oct. 1985 Report will also be announced as translation (ESA-TT-945)
(DFVLR-MITT-85-04; ISSN-0176-7739) Avail: NTIS HC A10/MF A01

Motor glider meteorology and the history of motor gliders used for meteorological flight are reviewed. Vertical wind velocity determination using aircraft motion is discussed. Meteorological data from the Falcon aircraft and the ASK 16 motor glider are compared. Atmospheric boundary layer turbulence is investigated. Environmental meteorological data in urban areas are examined. The concept of Lagrangian partitioning was applied to turbulent energy transport. Horizontal and vertical structure of the boundary layer, and the energy budgets above rural and urban areas are treated. Lee circulation in a Foehn wind is studied. Meteorological measuring campaigns with instrumented motor gliders in Poland are reviewed. A data acquisition system for meteorological measurements onboard light aircraft is developed. Accuracy and error analysis of meteorological measuring data is considered. The principles of wind velocity measurements onboard research aircraft are presented.

**N85-35543#** Bonn Univ. (West Germany). Inst. fuer Meteorologie.

**MOTOR GLIDER METEOROLOGY [MOTORSEGLER-METEOROLOGIE]**

H. KRAUS *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 P 11-13 Jan. 1985 In GERMAN
Avail: NTIS HC A10/MF A01

Methods of dividing meteorological sciences in partial domains are given, and the requirements and tasks of motor glider meteorology are depicted. It is explained that motor gliders are especially suited for the experimental determination of processes and structures on a micro and mesoscale and of micro-mesoscale interactions. Author (ESA)

**N85-35545#** Eidgenoessisches Inst. fuer Reaktorforschung, Wuerenlingen (Switzerland).

**DETERMINATION OF VERTICAL AIR VELOCITY USING MEASUREMENTS OF THE AIRCRAFT MOTION [BESTIMMUNG DER VERTIKALGESCHWINDIGKEIT DER LUFT MIT HILFE VON MESSUNGEN DER FLUGZEUGBEWEGUNG]**

M. HUTTER *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 29-42 Jan. 1985 refs In GERMAN
Avail: NTIS HC A10/MF A01

Absolute air velocity is determined from the movements of an aircraft. Determination of aircraft motion in a vertical plane is described; the vertical equation of motion and the calculation of an average position angle are discussed. Good agreement is found between measured and calculated angles. The sensitivity of the results to the position angle is discussed. Author (ESA)

**N85-35546#** Technische Univ., Brunswick (West Germany). Inst. fuer Flugfuehrung.

**CONTROL VARIABLES IN VERTICAL WIND DETERMINATION USING SIMPLE FLIGHT-MECHANICAL EQUATIONS [EINFLUSSGROESSEN BEI DER VERTIKALWINDBESTIMMUNG MIT EINFACHEN FLUGMECHANISCHEN GLEICHUNGEN]**

K. U. HAHN and C. J. JIN *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 43-60 Jan. 1985 refs In GERMAN
Avail: NTIS HC A10/MF A01

A measuring method for the determination of the vertical wind velocity using small measuring aircraft (e.g., motor gliders) is developed. During the flight through a wind field, wind velocity fluctuations act on the aircraft in the form of additional forces. Aircraft reactions to these perturbations depend strongly on the steering maneuvers of the pilot. From this response behavior of the aircraft conclusions can be drawn as to the wind behavior if the aircraft dynamics are precisely known. The wind determination procedure can be simplified if only vertical wind is taken into account and if stationary behavior is assumed. The validity domain of these simplifying assumptions and the effect of measuring quantity errors (investigated by simulations) are discussed. Author (ESA)

**N85-35547#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.

**A COMPARISON BETWEEN FALCON DATA AND MOTOR GLIDER DATA [EIN VERGLEICH VON FALCON-DATEN MIT MOTORSEGLER-DATEN]**

H. WILLEKE *In its* Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 61-68 Jan. 1985 refs In GERMAN
Avail: NTIS HC A10/MF A01

The data of the Falcon aircraft and the ASK 16 motor glider meteorological flight under the same meteorological conditions are compared to estimate errors in the determination of the vertical wind component. Flight data and equipment of both aircraft are listed. The flight programs, data evaluation, and comparison method are described. The parameters measured by both aircraft are listed. The power spectra to the vertical velocity show good agreement. The differing relative deviations in heat fluxes shows that at least one unknown effect occurs. Author (ESA)

**N85-35548#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.

**CASE STUDIES FOR FLUX MEASUREMENTS ALONG A LOW-FLYING ROUTE TO THE SOUTH OF MUNICH [FALLSTUDIEN ZU FLUSSMESSUNGEN ENTLANG EINER TIEFFLUGSTRECKE SUEDLICH VON MUENCHEN]**

M. E. REINHARDT *In its* Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 69-79 Jan. 1985 refs In GERMAN

Avail: NTIS HC A10/MF A01

Turbulent, sensible, and latent heat fluxes along low flying motor glider routes are measured to study the atmospheric boundary layer. The behavior of sensible and latent heat fluxes on days with different meteorological conditions is discussed. Normalized frequency distributions of all measured vertical accelerations during measuring of flights are shown. Improvements of the measuring strategy are proposed to allow deeper analysis of the fine structure of atmospheric boundary layer phenomena. Author (ESA)

**N85-35549#** Eidgenoessisches Inst. fuer Reaktorforschung, Wuerenlingen (Switzerland).

**ENVIRONMENTAL-PHYSICAL MEASUREMENTS AND DETERMINATION OF ATMOSPHERIC TURBULENCE WITH THE ASK-16 MOTOR GLIDER [UMWELTPHYSIKALISCHE MESSUNGEN UND ERFASSUNG ATMOSPHAERISCHER TURBULENZ MIT DEM MOTORSEGLER ASK-16]**

M. HUTTER *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 81-89 Jan. 1985 refs In GERMAN

Avail: NTIS HC A10/MF A01

Meteorological motor glider flights are performed to determine environmental and atmospheric turbulence parameters. Temperature and humidity probes used in the project CLIMOD (climate modification) studying the effect of increasing urbanization and planned nuclear power plants with their cooling system on the climate, and the results of the measurements and model calculations are discussed. Ozone in the lower troposphere due to the existence of smog reactions in the neighborhood of Zurich is investigated in ground stations and with two captive balloons; the regional ozone distribution was measured by motor gliders; the measurements strongly point at the Zurich agglomeration as the origin of the ozone-rich air. The motions of motor gliders due to air flows are used to determine atmospheric turbulence in the wavelength domain between 10 and 100 m; the measurements confirm previous results: agreement between the measurements and a mathematical turbulence parameterization model is found. Author (ESA)

**N85-35550#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.

**MEASUREMENTS FOR THE DETERMINATION OF THE VERTICAL STRUCTURE OF THE CONVECTIVE BOUNDARY LAYER [MESSUNGEN ZUR VERTIKAL STRUKTUR DER KONVEKTIVEN GRENZSCHICHT]**

A. M. JOCHUM *In its* Proc. of Meteorol. Motor Glider (MEMO) '84 Workshop p 91-97 Jan. 1985 refs In GERMAN

Avail: NTIS HC A10/MF A01

A meteorological measuring compaign with motor gliders is performed to investigate turbulent vertical transport in the convective boundary layer and the spatial structure of thermal air fields. The measuring procedures are described. The vertical profiles measured and normalized (mixed-layer scaling) can be well integrated in the framework of similar profiles. Author (ESA)

**N85-35551#** Bonn Univ. (West Germany). Inst. fuer Meteorologie.

**PARTITIONING OF THE VERTICAL TURBULENT ENERGY TRANSPORT INTO POSITIVE AND NEGATIVE CONTRIBUTIONS [AUFSPALTUNG DER VERTIKALEN TURBULENTEN ENERGIETRANSPORTE IN POSITIVE UND NEGATIVE BEITRAEGE]**

J. M. HACKER *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 99-114 Jan. 1985 refs In GERMAN

Avail: NTIS HC A10/MF A01

The concept of Lagrangian partitioning is applied to motor glider meteorological flight measuring series in order to study which single processes contribute to the turbulent net vertical transport of sensible and latent heat. Normalization and data evaluation procedures are described. It is found that in the upper level of the inversion layer the net fluxes consist of much higher single contributions than in the lower level, especially for the sensible heat flux. At both levels the moist, then hot, wakes give the largest contribution to the direct circulations, while the hot wakes give the largest contribution to the indirect circulations. For sensible heat the intensities of the processes due to hot air dominate at both levels. For latent heat the intensities of the processes due to moist air only dominate at the lower level. Author (ESA)

**N85-35552#** Bonn Univ. (West Germany). Inst. fuer Meteorologie.

**AIRCRAFT MEASUREMENTS DURING THE BONN EXPERIMENT (BONEX 1) [DIE FLUGZEUGMESSUNGEN WAEHREND DES EXPERIMENTES BONEX 1]**

V. KESPE *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 115-133 Jan. 1985 refs In GERMAN

Avail: NTIS HC A10/MF A01

Meteorological measurements are performed to investigate the horizontal and vertical structure of the atmospheric boundary layer. Two captive balloon systems, an energy budget station, and instrumented motor gliders are used. The synoptic measuring situation is described. The effect of the mask on the motor glider measurements of the lowest flight level is discussed. The spatial and temporal variation of the standard deviations of vertical wind velocity, potential temperature, and specific humidity, and of the correlation coefficients, as well as the turbulent fluxes of sensible and latent heat are obtained. The profile of the standard deviations are discussed. Author (ESA)

**N85-35554#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.

**THE DETERMINATION OF LEE CIRCULATION DURING THE FOEHN WIND [ZUR BESTIMMUNG DER LEE-ZIRKULATION BEI FOEHN]**

K. P. HOINKA *In its* Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 143-149 Jan. 1985 refs In GERMAN

Avail: NTIS HC A10/MF A01

A field experiment, including measurements with motor gliders, are conducted to determine the circulation above and in the lee of the Alps during the foehn wind. Pressure, temperature, and humidity are measured and the isentropes are analyzed. Flow lines and trajectories agree with the isentropes, under the assumption that the flow is two-dimensional, frictionless, and adiabatic. The results show that motor gliders can provide an important contribution to the investigation of partial problems, as in the case of foehn, especially in connection with other measurements and investigation methods. Author (ESA)

**N85-35555#** Warsaw Univ. (Poland). Inst. of Geophysics.

**METEOROLOGICAL MEASUREMENTS WITH MOTOR GLIDERS IN POLAND**

S. P. MALINOWSKI *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 151-156 Jan. 1985 refs

Avail: NTIS HC A10/MF A01

Meteorological measuring campaigns with instrumental motor gliders study small scale humidity and temperature inhomogeneities

caused by dissipating cumulus clouds; and the invisible parts of cooling tower plumes. A program to investigate entrainment and mixing processes in small cumulus clouds is outlined. The motor glider instrumentation and the specification of the measuring unit are presented. The motor glider SZD-45 Ogar is described.
Author (ESA)

**N85-35557#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Flugmechanik.

**ACCURACY AND ERROR ANALYSIS [GENAUIGKEITS- UND FEHLERANALYSE]**

J. SKUDRIDAKIS *In its* Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 161-194 Jan. 1985 refs In GERMAN
Avail: NTIS HC A10/MF A01

Accuracy estimation and error analysis of physical quantities measured during flights are treated. The standard deviation of the Gaussian distribution as criterion for the uncertainty of the measured quantity is discussed. Accuracy estimates via the covariance matrices of the state and measurement equations, and via system identification are explained. The effect of the measurement precision, and a dynamic angle of attack equation are given. The example of air and recovery temperature measurement is presented. Author (ESA)

**N85-35558#** Technische Univ., Brunswick (West Germany). Inst. fuer Flugfuehrung.

**THE PRINCIPLES OF WIND MEASUREMENT WITH THE HELP OF AIRCRAFT [GRUNDLAGEN DER WINDMESSUNG MIT HILFE VON FLUGZEUGEN]**

P. VOERSMANN *In* DFVLR Proc. of Meteorol. Motor Glider (MEMO) Workshop '84 p 195-205 Jan. 1985 refs In GERMAN; ENGLISH summary
Avail: NTIS HC A10/MF A01

The three components of the wind vector are computed in real time by taking the difference between the inertial velocity and the true airspeed. To perform this calculation, it is necessary to transform the true airspeed from the aerodynamic to the Earth-fixed coordinate system. This coordinate transformation contains numerous trigonometric functions (sine and cosine functions), which yield nonlinear relations for the determination of the wind vector components. These relations present the theoretical principles for measuring winds onboard an aircraft. Author (ESA)

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## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A85-48099**

**FAST-JET AIRCREW SAFETY**

J. FARLEY (British Aerospace, PLC, Dunsfold, England) Flight International (ISSN 0015-3710), vol. 128, Aug. 31, 1985, p. 25-29.

An evaluation is made of tactical combat aircraft crew safety equipment development and performance, with specific reference to RAF experience with Hawk and Harrier fighter crew ejection incidents. The conditions for maximum likelihood of survivability and minimization of injuries are assessed for various aircrew equipment assemblies (encompassing helmets and oxygen masks, life preservers, personal equipment connectors, antigravity suits, emergency intercoms, and seats and harnesses), in light of recorded crew ejection and man/seat separation cases. O.C.

**A85-48860**

**FLIGHT MANAGEMENT SYSTEMS CREATE NEW CREW TRAINING NEEDS**

M. K. DEJONGE (Lear Siegler, Inc., Instrument Div., Grand Rapids, MI) ICAO Bulletin, vol. 40, May 1985, p. 29-31.

Flight Management Computer Systems (FMCS) are now part of every newly introduced aircraft. These systems interface with the pilot through a control/display unit, the design of which varies considerably according to the manufacturer of the aircraft or the FMCS, making it necessary to train the pilot for every new or upgraded FMCS. To supplement the training manuals, the existing audio-visual slide-show packages, and the touch-screen systems, a novel hands-on method involving a table-top flight simulator interfaced with the actual FMCS hardware has been introduced. In a set-up developed for Boeing, the FMCS for the B-737-300 is interfaced with an inexpensive Commodore personal computer, which is programmed to provide a simulator of the flight instruments and controls, the autopilot, autothrottle, and the aircraft and engine dynamics, enabling the students to operate the FMCS in a dynamic flight situation, with an aircraft's own navigation data base in the FMCS. I.S.

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## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A85-47675**

**1984 AMERICAN CONTROL CONFERENCE, SAN DIEGO, CA, JUNE 6-8, 1984, PROCEEDINGS. VOLUMES 1, 2 & 3**

Conference sponsored by the American Automatic Control Council. New York, IEEE, 1984, Vol. 1, 623 p.; vol. 2, 628 p.; vol. 3, 772 p. For individual items see A85-47677 to A85-47803.

The topics considered are related to the modeling of human cognitive decision processes, sensor-based robot control systems, adaptive control and applications, modelling and simulation of thermofluid processes and systems, advanced concepts for computer-aided control system design, model reduction and large scale systems, fuel-optimal aircraft guidance and control, and digital signal processing. Other subjects explored are concerned with the dynamical systems approach to problems in nonlinear systems and control, monitoring and fault detection in power systems, robot path planning and control, the real time control of processes, pole placement design, large scale systems and model reduction, and aircraft control. Attention is also given to servomechanisms and machine tool control, stochastic systems, process model-based control and analysis, applications of multivalued logic, microprocessor implementation of real time control systems using high order languages, multitarget tracking, digital systems, filtering and estimation, optimal control, and fault tolerant aerospace systems. G.R.

**A85-47681**

**PARAMETER SPACE DESIGN OF CONTROL SYSTEMS USING INTERACTIVE COMPUTER GRAPHICS**

P. PUTZ and M. J. WOZNY (Rensselaer Polytechnic Institute, Troy, NY) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 105-114. Research supported by the Rensselaer Polytechnic Institute and General Electric Co. refs
(Contract NSF ISP-70-20240)

This paper presents contributions to computer-aided control system design in the parameter space approach. Newly developed modeling algorithms allow the use of three-dimensional interactive computer graphics as a powerful and very flexible tool for multivariable control system design. Robustness with respect to plant variation and sensor failures, actuator constraints, sensor noise and quantization effects in addition to specifications about stability, damping, and bandwidth are handled in a direct geometric way by working with admissible regions of several design parameters. An interactive CAD software package with these capabilities is discussed and several design examples demonstrate the potential and versatility of the method. Author

**A85-47704*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**A REAL-TIME FORTRAN IMPLEMENTATION OF A SENSOR FAILURE DETECTION, ISOLATION AND ACCOMMODATION ALGORITHM**
J. C. DELAAT (NASA, Lewis Research Center, Cleveland, OH) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 572, 573. refs

An advanced, sensor failure detection, isolation, and accomodation algorithm has been developed by NASA for the F100 turbofan engine. The algorithm takes advantage of the analytical redundancy of the sensors to improve the reliability of the sensor set. The method requires the controls computer, to determine when a sensor failure has occurred without the help of redundant hardware sensors in the control system. The controls computer provides an estimate of the correct value of the output of the failed sensor. The algorithm has been programmed in FORTRAN using a real-time microprocessor-based controls computer. A detailed description of the algorithm and its implementation on a microprocessor is given. I.H.

**A85-47735*** Drexel Univ., Philadelphia, Pa.
**MODAL INSENSITIVITY WITH OPTIMALITY**
A. J. CALISE and K. V. RAMAN (Drexel University, Philadelphia, PA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 949-953. refs
(Contract N00014-77-C-0642; NAG1-243)

This paper deals with the design of a constant gain, feedback controller which results in selected modal insensitivity, and at the same time optimizes a quadratic performance index representative of desired system performance for nominal plant parameter values. Both full state and output feedback control are considered. A constraint is established for the feedback gain matrix that results in modal insensitivity, and necessary conditions for optimality subject to this constraint are given. This forms the basis for a numerical algorithm to compute the optimal feedback gain. To illustrate the procedure, a design is carried out using the lateral dynamics of an L-1011 aircraft. Author

**A85-47769**
**A NEW APPROACH TO THE MANEUVERING TARGET TRACKING PROBLEM**
N. O. SPEAKMAN (USAF, Armament Laboratory, Eglin AFB, FL) and T. E. BULLOCK (Florida, University, Gainesville) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1404, 1405. refs

A description is given of the theoretical basis for a new autoregressive moving-average (ARMA) model identification method. Attention is given to an algorithm which determines the minimum order n of an ARMA model, relationships to the Kalman filter, and applications to target dynamic modelling. By applying a new method to an identification of ARMA model parameters, it is shown that a simulated aircraft acceleration can be accurately modeled with ARMA models. Applications to the design of tracking filter dynamic models appear to be obvious. G.R.

**A85-47774**
**A DISTRIBUTED AEROACOUSTIC TRACKING ALGORITHM**
R. R. TENNEY (MIT, Cambridge, MA) and J. R. DELANEY (MIT, Lexington, MA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1440-1450. DARPA-supported research. refs

A distributed algorithm is being developed for tracking very-low-flying, subsonic aircraft using geographically dispersed acoustic sensors and colocated data processors linked by a digital radio broadcast communication network. Development of the algorithm serves as a case study of the applicability and limitations of state-of-the-art distributed estimation theory. Three major components of the algorithm are described: the local estimation algorithm, the distributed estimation algorithm, and the communications policy. The local estimation algorithm uses single sensor measurements to improve state estimates in one sensor/processor node. The distributed estimation algorithm combines state estimates computed at different nodes. The communications policy governs the exchange of state estimates between nodes. Performance of the algorithm in simulated tracking experiments is reported. Author

**A85-47784**
**COMPUTER-AIDED DESIGN OF CONTROL SYSTEMS VIA PARAMETER OPTIMIZATION METHOD (CADCS/POM) - AN INTERACTIVE GRAPHICS APPROACH**
T. SADEGHI (Fairchild Republic Co., Farmingdale, NY) and M. WOZNY (Rensselaer Polytechnic Institute, Troy, NY) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1634-1640. refs

This paper describes an interactive graphics approach for computer-aided design of control systems via a parameter optimization method. The approach integrates: (1) an optimal proportional-plus-integral control law to achieve tracking, (2) an algorithmic optimization technique to satisfy linear and non-linear constraints, and (3) an interactive graphics approach to utilize the heuristic optimization (human knowledge, experience, and intuition). Where each of the preceding concepts has its unique features, the integrated aproach allows minimization of computer and design time beyond minimizing a cost function. Author

**A85-47793*** Massachusetts Inst. of Tech., Cambridge.
**CONTROL SYSTEM RECONFIGURATION**
W. E. VANDER VELDE (MIT, Cambridge, MA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1741-1745.
(Contract NAG1-126)

The problem of reconfiguring a control system to accommodate the failure of a sensor or actuator is discussed in the context of several different system configurations. First, some ground rules under which the reconfiguration algorithms are to function are established. A variety of control system configurations is then considered, and it is found that the approach to reconfiguration is obvious in some cases but not clear in others. Several possible strategies for reconfiguration, applicable to different situations, are examined. V.L.

**A85-48024**
**COMPUTER AND INFORMATION TECHNOLOGY IN THE YEAR 2000 - A PROJECTION**
S. F. LUNDSTROM (Microelectronics and Computer Technology Corp., Austin, TX) and R. L. LARSEN (Maryland, University, College Park) Computer (ISSN 0018-9162), vol. 18, Sept. 1985, p. 68-79. refs

The reasoning and conclusions drawn by a panel of experts from the National Research Council who, at the request of NASA, considered information and computer technologies which would be available in the year 2000 are reported. The deliberations covered microelectronics and components, processors, software, AI and expert systems, man-machine interfaces, systems development and implementation and high-integrity systems. It was projected that components would be 2-3 orders of magnitude more cost- and size-effective by the turn of the century. Airborne systems would carry 50 Mb RAM and perform operations at 1 GIPS. Supercomputers would have been pushed to 1 Tflops with 10 Gwords of RAM and 100-100,000 processing elements. The parallel progress in aerospace technologies will directly depend on the degree aerospace engineers access the new computing power. M.S.K.

**A85-49005**
**RECENT ADVANCES IN COMPUTER IMAGE GENERATION**
P. K. DOENGES (Evans and Sutherland Computer Corp., Salt Lake City, UT) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 27-38.

Polygon/area Computer Image Generation (CIG) technology, currently known in product form as CT5, employs parallel processing in order to expand the number of display channels and raster resolution; it also incorporates strongly hierarchical database management and culling. CIG architecture has demonstrated configuration flexibility and growth potential; attention is presently given to the last five years' experience with applications of the CT5 architecture, as well as to the prospects for meeting advanced operational and functional performance objectives with such an architecture in the future. O.C.

**A85-49531#**
**ITAD - A CAD SYSTEM FOR ENVIRONMENTAL RELIABILITY DESIGN**
A. H. MAYER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 23-26.
(Contract F33615-79-C-3421)

The paper describes the ITAD (Integrated Thermal Avionic Design) Computer Aided Design for Reliability System from the points of view of development objectives, design features, development experiences, development status, future possibilities and illustrates a currently operational design scenario for the optimal reliability, minimum life cycle cost placement of electronic parts on a circuit card. Author

**A85-49570*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A USER'S VIEW OF CARE III**
S. J. BAVUSO (NASA, Langley Research Center, Hampton, VA) IN: Annual Reliability and Maintainability Symposium, San Francisco, CA, January 24-26, 1984, Proceedings . New York, IEEE, 1984, p. 382-389. refs

The present computerized reliability predictor for digital fault-tolerant systems whose sizes are of the order of one million Markovian equivalent states, employs advanced stochastic modeling techniques and implements a mixed Markov model that enables it to drastically reduce the state size of hitherto computationally unobtainable models. Attention is given to the concepts of failure, fault, and error, in the context of the novel system's fault/error-handling models. Examples are drawn from the system's user-friendly interface dialog. O.C.

**N85-34510*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**THE IMPACT OF SUPERCOMPUTERS ON EXPERIMENTATION: A VIEW FROM A NATIONAL LABORATORY**
V. L. PETERSON and J. O. ARNOLD Aug. 1985 16 p refs
(NASA-TM-86822; REPT-85377; NAS 1.15:86822) Avail: NTIS HC A02/MF A01 CSCL 09B

The relative roles of large scale scientific computers and physical experiments in several science and engineering disciplines are discussed. Increasing dependence on computers is shown to be motivated both by the rapid growth in computer speed and memory, which permits accurate numerical simulation of complex physical phenomena, and by the rapid reduction in the cost of performing a calculation, which makes computation an increasingly attractive complement to experimentation. Computer speed and memory requirements are presented for selected areas of such disciplines as fluid dynamics, aerodynamics, aerothermodynamics, chemistry, atmospheric sciences, astronomy, and astrophysics, together with some examples of the complementary nature of computation and experiment. Finally, the impact of the emerging role of computers in the technical disciplines is discussed in terms of both the requirements for experimentation and the attainment of previously inaccessible information on physical processes. Author

**N85-34596** Societe Francaise d'Instruments de Mesure, Massy (France).
**IMPLICATIONS OF ARTIFICIAL INTELLIGENCE ON THE DESIGN OF FUTURE ONBOARD SYSTEMS Final Report [IMPLICATIONS DE L'INTELLIGENCE ARTIFICIELLE SUR LA CONCEPTION DES SYSTEMES EMBARQUES FUTURS]**
T. BILLOIR Dec. 1984 80 p refs In FRENCH
(Contract DRET-83-1423)
(SFENA-DPS/C/S3/84252A) Avail: Issuing Activity

The applicability of artificial intelligence to aircraft or spacecraft design is discussed. A progress report on the research and development of the AMES airborne maintenance expert system is included. Author (ESA)

## 16
## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A85-47309**
**A MORE MODERN THEORY OF COMBUSTION NOISE**
W. C. STRAHLE (Georgia Institute of Technology, Atlanta) IN: Recent advances in the aerospace sciences . New York, Plenum Press, 1985, p. 103-114. refs
(Contract NSF CME-80-22366)

Some of the newer concepts that have emerged in the theory of turbulent reacting flows are applied to the problem of combustion-generated noise. A general theory is constructed for noise radiation from a turbulent combustion region in the practical limit of low frequency and low Mach number. The theory is specialized to simple cases of premixed and nonpremixed jet flames radiating to a free field. Comparison with experiment is given for premixed flames. A new interpretation is given for the frequency content of combustion noise, which is in accord with experiment. Author

**A85-48179**
**PARAMETRIC ANALYSIS OF THE ACOUSTIC POWER EMITTED BY COAXIAL JETS**
V. F. SAMOKHIN (TsAGI, Uchenye Zapiski, vol. 15, no. 1, 1984, p. 55-64) Fluid Mechanics - Soviet Research (ISSN 0096-0764), vol. 12, Nov.-Dec. 1983 (1985), p. 26-36. Translation. refs

An analytic model is suggested for calculating the acoustic power of coaxial jets at different degrees of initial turbulence of the outer jet. A parametric analysis of the acoustic power emitted by isothermal and nonisothermal coaxial jets is performed. Formulas for optimum parameters of jets, ensuring minimum acoustic emission power, are presented. Author

**A85-48527#**
**EXPERIMENTAL RESULTS ON EDGE-TONE OSCILLATIONS IN HIGH-SPEED SUBSONIC JETS**
J. LEPICOVSKY and K. K. AHUJA (Lockheed-Georgia Co., Marietta, GA) AIAA Journal (ISSN 0001-1452), vol. 23, Oct. 1985, p. 1463-1468. Research sponsored by the Lockheed-Georgia Co. Previously cited in issue 10, p. 1473, Accession no. A83-25902. refs

**A85-49137#**
**ACOUSTIC INTENSITY TECHNIQUES FOR AIRPLANE CABIN APPLICATIONS**
G. A. DALAN and R. L. COHEN (Boeing Commercial Airplane Co., Seattle, WA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Oct. 1985, p. 910-914. Previously cited in issue 10, p. 1475, Accession no. A83-25931. refs

**A85-50110**
**NOISE TRANSMISSION CHARACTERISTICS OF AIRCRAFT-TYPE COMPOSITE PANELS**
V. L. METCALF (U.S. Army, Research and Technology Laboratories, Hampton, VA) and F. W. GROSVELD (Bionetics Corp., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 18 p. refs
(SAE PAPER 850878)

The noise transmission loss characteristics of 28 flat, fiber reinforced, composite panels and 4 aluminum panels, with dimensions of 24.1 cm by 40.6 cm, have been experimentally investigated in the NASA Langley Research Center noise transmission loss apparatus. To support the acoustic data, modal frequencies and modal damping for several mode shapes of each of the test panels were extracted experimentally, using impulse testing with a Computer Aided Test system. It was determined that the modal frequencies and damping ratios are affected by the fiber orientation in the composite panel. The transmission loss of composite panels is compared with that of aluminum panels of equal critical shear load. The effects of applying structural foam and damping material are indicated. Author

**N85-34717#** Rolls-Royce Ltd., Derby (England). Materials Engineering Group.
**COST EFFECTIVE SINGLE CRYSTALS: THE ROLLS ROYCE APPROACH**
M. J. GOULETTE, P. D. SPILLING, and R. P. ARTHEY 1 Nov. 1984 11 p refs Presented at 5th Intern. Symp. on Superalloys, Seven Springs, England, 1984
(PNR-90262) Avail: NTIS HC A02/MF A01

The development of a cost effective single crystal technology, including single crystal casting technique, alloy development, and orientation measurement, is described. The first aspect led to the adoption of the technically more difficult seeding technique as a result of its greater flexibility. The second resulted in the development of a series of three alloys to meet specific turbine applications. The third requirement is met by the development of a rapid and accurate orientation measurement technique suitable for the production environment. Author (ESA)

**N85-35690#** Deputy Chief of Staff for Research Development and Acquisition (Army), Washington, D.C.
**PROCEEDINGS OF THE 14TH ARMY SCIENCE CONFERENCE. VOLUME 2: PRINCIPAL AUTHORS I THROUGH O**
1984 368 p refs Conf. held at West Point, N.Y., 19-21 Jun. 1984 5 Vol.
(AD-A149201) Avail: NTIS HC A16/MF A01 CSCL 05B

Progress and results in military science, technology, and research and development was presented at the 1984 Army Science conference. E.A.K.

**N85-35695*#** Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
**A RESEARCH PROGRAM TO REDUCE THE INTERIOR NOISE IN GENERAL AVIATION AIRCRAFT, INDEX AND SUMMARY**
L. MORGAN, K. JACKSON, and J. ROSKAM Aug. 1985 63 p
(Contract NSG-1301)
(NASA-CR-176178; NAS 1.26:176178; KU-FRL-417-24) Avail: NTIS HC A04/MF A01 CSCL 20A

This report is an index of the published works from NASA Grant NSG 1301, entitled A Research Program to Reduce the Interior Noise in General Aviation Aircraft. Included are a list of all published reports and papers, a compilation of test specimen characteristics, and summaries of each published work. Author

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A85-49613**
**HOW MUCH DOES IT COST/HOW MUCH DOES IT WEIGH?**
T. E. BRENTS, JR. (General Dynamics Corp., Fort Worth, TX) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 30 p.
(SAWE PAPER 1593)

Attention is given to cost estimation method trends in the U.S. military aircraft industry, where weight-drive parametric estimation has been used for such products as the F-16 fighter in order to deliver firm prices on proposed changes. Parametric estimates are also used to provide customers with budgetary information. The engineering change proposal pricing practices presently detailed were first applied in the negotiation of a pricing agreement for tooling in 1980. O.C.

**A85-49914**
**WEIGHT CONTROL - A PROCUREMENT AGENCY PERSPECTIVE**
D. M. CATE (U.S. Naval Air Systems Command, Washington, DC) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 14 p.
(SAWE PAPER 1594)

A procurement agency perspective on the factors which make success in weight control efforts difficult to achieve is presented, with attention to technological uncertainty, psychological pressures toward optimistic estimates, insufficient resources, and competing priorities. It is suggested that these factors can be significantly balanced by undertaking weighings for estimate verification, by the use of derivation and modification programs, and by means of center-of-gravity control. O.C.

**N85-35811#** DOD Product Engineering Services Office, Alexandria, Va.
**DOD VALUE ENGINEERING CONFERENCE REPORT. VALUE ENGINEERING (VE): A TOOL THAT BENEFITS LINE MANAGEMENT HELD AT LEESBURG, VIRGINIA ON 1-2 NOVEMBER 1984. PART 2. PLENARY SESSION**
G. FRANK and L. PAULSON Jun. 1985 246 p Conf. held at Leesburg, Va., 1-2 Nov. 1984
(AD-A156068) Avail: NTIS HC A11/MF A01 CSCL 05A

This Conference Report summarizes and consolidates the proceedings from the 1984 DOD Value Engineering Conference held 1 through 2 November in Leesburg, VA. The findings and recommendations with supporting material from the five workshops are provided in addition to the complete plenary session presentations. An Executive Summary is presented in Part 1. Plenary Session: Moving Value Engineering Conference, The Hughes Aircraft Company Approach to Value Engineering, E-3A Value Engineering, FMC Value Engineering Program, FAR/DoD FAR Supplement, VECPs - the IG View, Collateral Savings - The Real Challenge, Where's the Map?, and A Value Engineering Coordinator's Preception of the DOD Value Engineering Program. GRA

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## SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

**N85-34766*#** Aerospace Corp., El Segundo, Calif. Space Sciences Lab.

**A SEARCH FOR SOLAR NEUTRONS ON A LONG DURATION BALLOON FLIGHT**

R. KOGA, G. M. FRYE, JR. (Case Western Reserve Univ.), A. OWENS (Case Western Reserve Univ.), B. V. DENEHY (Melbourne Univ., Parkville, Australia), O. MACE (Melbourne Univ. Parkville, Australia), and J. THOMAS (Melbourne Univ., Parkville, Australia) *In* NASA. Goddard Space Flight Center 19th Intern. Cosmic Ray Conf., Vol. 4 p 142-145 Aug. 1985 refs Sponsored in part by the Royal Australian AF, and by Australian Research Grants Committee

(Contract NSF ATM-82-06044)

(SH-1.4-6) Avail: NTIS HC as boxed set only $200/MF A01 per volume or E99 per entire set CSCL 03B

The EOSCOR 3 detector, designed to measure the flux of solar neutrons, was flown on a long duration RACOON balloon flight from Australia during Jan. through Feb. 1983. The Circum-global flight lasted 22 days. No major solar activity occurred during the flight and thus only an upper limit to the solar flare neutrons flux is given. The atmospheric neutron response is compared with that obtained on earlier flights from Palestine, Texas. Author

**N85-35966*#** Bordeaux 1 Univ., Gradignan (France). Lab. de Physique Theorique.

**ULTRA HIGH ENERGY EVENTS IN ECHOS SERIES AND PRIMARY ENERGY SPECTRUM**

J. N. CAPDEVIELLE, J. IWAI (Tokyo Univ.), and T. OGATA (Tokyo Univ.) *In* NASA. Goddard Space Flight Center 19th Intern. Cosmic Ray Conf., Vol. 6 p 447-450 Aug. 1985 refs

(HE-3.7-9) Avail: NTIS HC as boxed set only $200/MF A01 per volume or E99 per entire set CSCL 03B

The compilation of ultra high energy jets suggests at present the existence of a bump in primary energy spectrum (with the standard concept of high energy collisions). The pseudo-rapidity distribution exhibits some typical anomalies, more than the (P sub t) behavior, which are (may be) the fingerprints of quark gluon plasma transition. The next results of Emulsion Chamber on Supersonic (ECHOS) will be in both cases determinant to confirm those tendancies, as well as an important effort of the cosmic ray community to develop in that sense a flying emulsion chamber experiment. Author

## 19

## GENERAL

**N85-35151*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LANGLEY AERONAUTICS AND SPACE TEST HIGHLIGHTS, 1984**

1984 89 p refs

(NASA-TM-87585; NAS 1.15:87585) Avail: NTIS HC A05/MF A01 CSCL 05D

The role of the Langley Research Center is to perform basic and applied research necessary for the advancement of aeronautics and space flight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. Some of the significant tests which were performed during calendar year 1984 in Langley test facilities are highlighted. The broad range of the research and technology activities at the Langley Research Center and the contributions of this work toward maintaining United States leadership in aeronautics and space research are illustrated. R.J.F.

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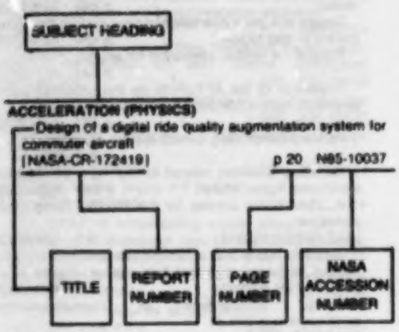

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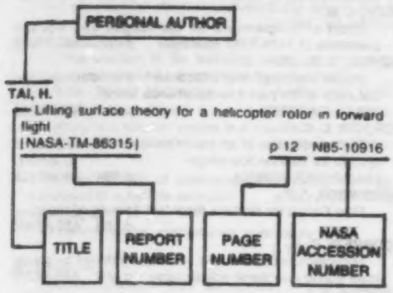

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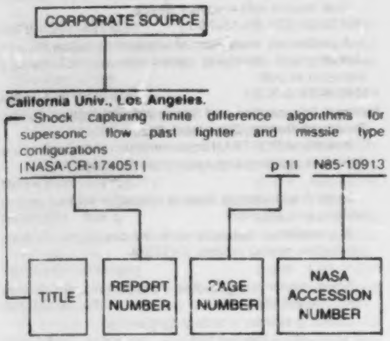
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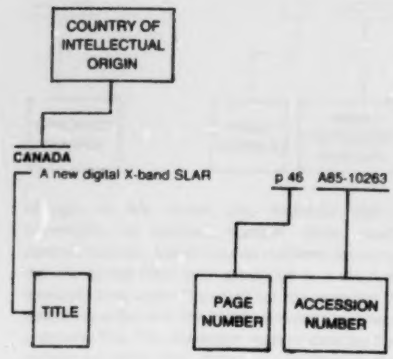

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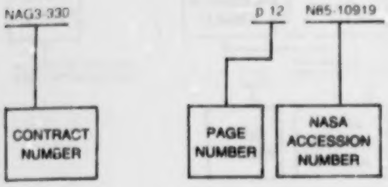

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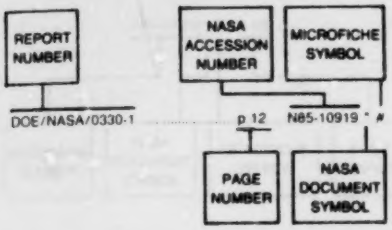

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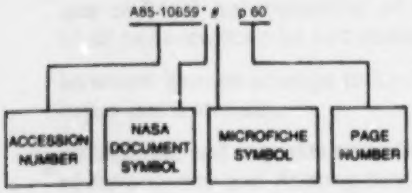

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**N85-10007*#** Boeing Commercial Airplane Co., Seattle, Wash.
**DEVELOPMENT AND APPLICATIONS OF ALGORITHMS FOR CALCULATING THE TRANSONIC FLOW ABOUT HARMONICALLY OSCILLATING WINGS**
F. E. EHLERS, W. H. WEATHERILL, and E. L. YIP Oct. 1984
152 p refs
(Contract NAS1-16297)
(NASA-CR-172376; NAS 1.26:172376) Avail: NTIS HC A08/MF A01 CSCL 01A

A finite difference method to solve the unsteady transonic flow about harmonically oscillating wings was investigated. The procedure is based on separating the velocity potential into steady and unsteady parts and linearizing the resulting unsteady differential equation for small disturbances. The differential equation for the unsteady velocity potential is linear with spatially varying coefficients and with the time variable eliminated by assuming harmonic motion. An alternating direction implicit procedure was investigated, and a pilot program was developed for both two and three dimensional wings. This program provides a relatively efficient relaxation solution without previously encountered solution instability problems. Pressure distributions for two rectangular wings are calculated. Conjugate gradient techniques were developed for the asymmetric, indefinite problem. The conjugate gradient procedure is evaluated for applications to the unsteady transonic problem. Different equations for the alternating direction procedure are derived using a coordinate transformation for swept and tapered wing planforms. Pressure distributions for swept, untaped wings of vanishing thickness are correlated with linear results for sweep angles up to 45 degrees. E.A.K.

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**A85-18511*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.
**A VORTEX-LATTICE METHOD FOR GENERAL, UNSTEADY AERODYNAMICS**
P. KONSTADINOPOULOS, D. F. THRASHER, D. T. MOOK, A. H NAYFEH, and L. WATSON (Virginia Polytechnic Institute and State University, Blacksburg, VA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Jan. 1985, p. 43-49. refs
(Contract N00014-79-C-0103; NSG-1262)

A general method of calculating unsteady, incompressible, inviscid, three-dimensional flows around arbitrary planforms has been developed. The method is an extension of the vortex-lattice technique. It is not limited by aspect ratio, camber, or angle of attack, as long as vortex breakdown does not occur above the surface of the wing and separation occurs only along sharp edges. As the wing performs arbitrary maneuvers, the position of the wake and the distribution of circulation on the wing and in the wake are obtained as functions of time. One desirable feature of the present method is its ability to treat steady lifting flows very efficiently. Several examples of steady and unsteady flows are presented. These include rectangular wings, with and without flaps, delta, and cropped delta wings. Author

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# TO
# A CONTINUING BIBLIOGRAPHY ON

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   AIRCRAFT PROTUBERANCES
   U PROTUBERANCES
   FLIGHT PERFORMANCE
   U FLIGHT CHARACTERISTICS

2. Narrower Term (NT) references refer the user to more specific headings in the same subject area, under which additional material on the subject may be found. For example:

   FLOW RESISTANCE
   NT AERODYNAMIC DRAG
   NT FRICTION DRAG
   NT SUPERSONIC DRAG

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Page 257 will be found in Supplement 187.

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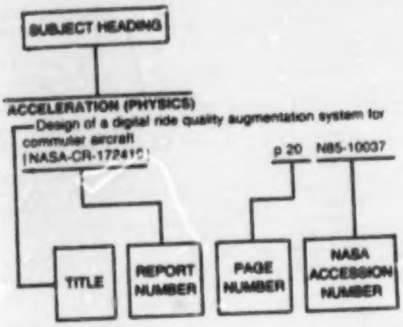

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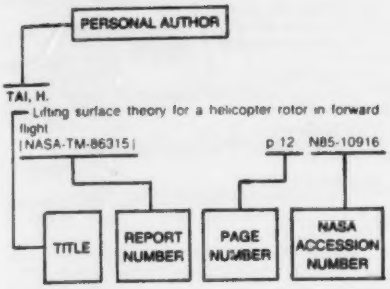

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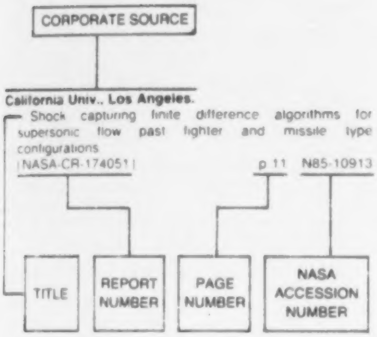
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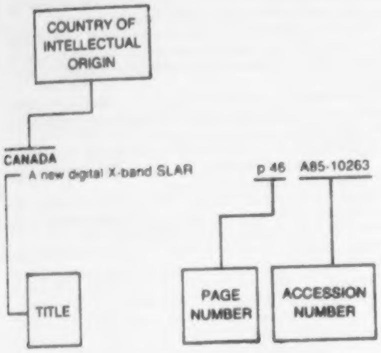

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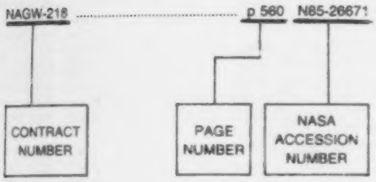

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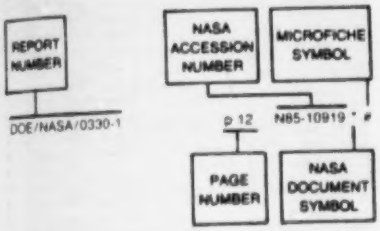

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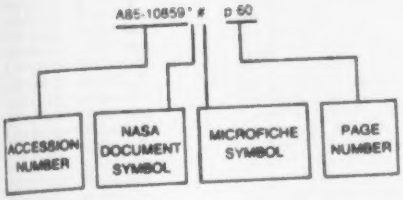

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# Aeronautical Engineering
A Continuing Bibliography with Indexes

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NASA SP-7037(197)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

## (Supplement 197)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in January 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Branch 1986
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Washington, DC

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 488 reports, journal articles, and other documents originally announced in January 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 197)*

FEBRUARY 1986

## 01

## AERONAUTICS (GENERAL)

**A86-10148#**
**AGONIES OF THE LEAR FAN**
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1985, p. 52-54, 56, 58, 60.

The design and attempted certification of the Lear Fan 2100 are discussed. The twin-turbine, single pusher prop aircraft, which was built with composites, is described. The costs incurred due to an effort to speed completion of a prototype resulted in new investors and work was centered on certification of the aircraft. Static and pressure testing were conducted; the problems encountered and the required redesigning are explained. The technique and composite used to build the structure are described. The FAA testing of the gearbox and the failures observed are discussed. The effects of testing full-size production structures are examined. I.F.

**A86-10351**
**REMOTELY PILOTED VEHICLES; INTERNATIONAL CONFERENCE, 4TH, BRISTOL, ENGLAND, APRIL 9-11, 1984, PROCEEDINGS AND SUPPLEMENTARY PAPERS**
Conference sponsored by the Royal Aeronautical Society and University of Bristol. Bristol, University of Bristol, 1984. Proceedings, 211 p.; Supplementary Papers, 48 p. For individual items see A86-10352 to A86-10376.

Among the topics discussed are: the operability of RPVs in bad weather; multi-mission RPV system experience; and the operational Eyrie multi-role all-weather advanced RPV system. Consideration is also given to: low cost-propulsion systems for unmanned vehicles; the aerodynamics of RPV airframes; and design standards for unmanned vehicles. Additional topics discussed include: launch and recovery systems for airborne RPVs; magnetic RPV guidance systems; and the development of a vertical gyroscope system for RPV applications. I.H.

**A86-10353**
**UNMANNED AIRCRAFT FOR THE ROYAL AIR FORCE?**
P. G. JENKINS (Logica UK, Ltd., London, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 2.1-2.7. refs

Some possible applications of unmanned aircraft for the Royal Air Force are discussed in connection with the state of the art of RPV design. Attention is given to the tactical advantages of operating an unmanned aircraft in a hostile battlefield environment including lower attrition; mission flexibility and lower man-hour maintenance costs. However, it is shown that shortcomings of current sensing and computing technologies continue to make manned aircraft a cheaper and more efficient alternative to military RPVs. The near term and long term uses of unmanned aircraft are described on the basis of their technological characteristics. Emphasis is given to the reconnaissance and electronic warfare roles of nonexpendable RPVs; and surveillance and target drones. It is shown that an autonomous squadron of ground launched RPVs of equal force effectiveness as a squadron of ALCM-armed aircraft would save over $1.6 billion over a 10 year period. I.H.

**A86-10356**
**MULTI-MISSION RPV SYSTEM EXPERIENCES**
G. R. SEEMANN, G. L. HARRIS, C. K. LAIR, and H. E. KRACHMAN (Developmental Sciences, Inc., City of Industry, CA) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 8.1-8.9.

The operational capabilities and design characteristics of a multi-role RPV system, the R4E-40 RPV, are described. The system is designed to carry a variety of telescopic and other sensors for real-time or way-point surveillance in hostile airspace. The control system of the R4E-40 consists of a three-axis autopilot coupled with quick-response servos for maximum stability in rough air. The R4E-40 can be launched by a mobile hydraulic launcher and is recoverable either by a landing ski or a cruciform parachute. Some of the payloads carried by the R4E-40 include: forward looking infrared sensors for target acquisition in low light; a panoramic film camera; and an infrared line scanner with a 120-degree cross track scan. Black and white photographs of the RPV system are provided. I.H.

**A86-10357**
**OPERATIONAL PHILOSOPHY OF INTERNATIONAL FULL-SCALE AERIAL TARGETS**
J. R. JACKSON (Sperry Flight Systems, Albuquerque, NM) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 9.1-9.9.

A program to convert obsolete aircraft for autonomous operation as target drones is described. The advantages of full scale aerial targets (FSATs) in comparison with subscale targets are considered, including: realistic threat simulation; greater payloads; and lower acquisition costs. Some safety features built into the QF-4 FSAT or the USAF are described including redundant command and control; a self-destruct system; and automatic loss-control computer routines. The sequence of events in a typical FSAT mission is shown in a diagram. I.H.

**A86-10359**
**NOW IS THE TIME FOR REMOTELY PILOTED HELICOPTERS**
R. G. AUSTIN and W. J. ALLDRIDGE (ML Aviation Co., Ltd., Bristol, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 11.1-11.14.

The development of small lightweight remotely piloted helicopters (RPHs) for battlefield surveillance applications is discussed. Some of the tactical advantages of small-scale RPV systems in today's dense military electronics environment are considered with emphasis given to the small radar and infrared signatures of RPHs; and their lower acquisition costs, i.e., expendability. The design characteristics of a prototype RPH system, the SPRITE, are described. The SPRITE is a dual rotor RPH which has a payload capacity of 6 kg and an endurance of about 2.5 hours per tank of fuel. The powerplant consists of two 6-bhp two-cycle engines. Electronic subsystems on the SPRITE include an on board alternator; a servomotor drive amplifier; and a command link airborne receiver. A photograph of the SPRITE RPH is provided. I.H.

**A86-10373**

### AREA SEARCH RATE AND IMAGE INTERPRETER PERFORMANCE

R. S. HARVEY (Army Personnel Research Establishment, Farnborough, England) and E. M. CARVER (British Aerospace, PLC, Bristol, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Supplementary Papers . Bristol, University of Bristol, 1984, p. 3.1-3.10.

A study by the Army Personnel Research Establishment (APRA) and the British Aerospace Human Factors Group (BAe) to determine the limits to image interpreter target aquisition performance for diverse area search rate conditions imposed by various factors is presented. The APRE method of simulated optical imagery and the BAe method of simulated infrared linescan imagery utilized to study area search rate are explained and compared. Both photographic interpreters and civilians participated in the test and tabular and graphic presentations of the results are provided. A comparison of the two methods based on imagery effects, terrain effects, air vehicle velocity, area search rate, method of presentation, and fields of view is presented. The results revealed that higher search rates are achieved with an IR linescan than with an optical sensor. I.F.

**A86-10375**

### TECHNOLOGY FOR MINI-RPV'S

H. WALD and V. SCHLENKRICH (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Supplementary Papers . Bristol, University of Bristol, 1984, p. 17.1-17.13.

The design of a mini-RPV system for real-time reconnaissance and surveillance and fire control for artillery and post strike reconnaissance is discussed. The operational requirements for the mini-RPV, the composition of the platoon, and the operational sequence are explained. The design requirements and advantages of the stabilization and point unit of the mini-RPV, which is based on roll/pitch axes gimbal stabilization, are described. A block diagram of the jam resistant data link, and an explanation of the main features of the system are presented. The use of stealth technology to camouflage the radar, infrared, acoustic, and visual signals of the mini-PRV is discussed. Diagrams, charts, and photographs explaining the mini-RPV are provided. I.F.

**A86-10928#**

### LOGISTICS SUPPORTABILITY CONSIDERATIONS DURING CONCEPTUAL AND PRELIMINARY DESIGN

D. P. SCHRAGE and S. A. MEYER (Georgia Institute of Technology, Atlanta) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. (AIAA PAPER 85-3052)

Big payoffs in aircraft life cycle costs and mission effectiveness can be achieved if logistic supportability considerations are adequately addressed during conceptual and preliminary design. Logistic supportability considerations must be sensitized and traded off like other quantifiable design parameters. With current aircraft design practices this has been difficult. This paper discusses methods to address logistic supportability trade-offs. The concept formulation effort for the U.S. Army's Light Helicopter Experimental (LHX) program is used to illustrate these methods. Author

**A86-10930*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### SOME COMPARISONS OF US AND USSR AIRCRAFT DESIGN DEVELOPMENTS

M. L. SPEARMAN (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 15 p. refs
(AIAA PAPER 85-3060)

A review is given of the design and development of some U.S. and U.S.S.R. aircraft. The emphasis is on the historical development of large aircraft - civil and military transports and bombers. Design trends are somewhat similar for the two countries and indications are that some fundamental characteristics are dictated more by ideological differences rather than technological differences. A brief description is given in a more or less chronological order of the major bomber aircraft, major civil and military transport aircraft, and the development of the air transport systems. Author

**A86-10950#**

### LHX PROGRAM OVERVIEW

R. K. ANDRESON (U.S. Army, Materiel Command, St. Louis, MO) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 5 p.
(AIAA PAPER 85-4006)

The LHX helicopter concept is being developed by the U.S. Army to serve as a replacement for existing UH-1, AH-1, OH-58 and OH-6 helicopters. The LHX will incorporate state of the art technology, provide higher readiness, lower support costs and improved safety, and will function in a variety of high threat environments. Two variants are planned: scout/attack (SCAT) and light utility, both being conventional rotorcraft. Advanced avionics, sensor fusion and flight control systems will obviate the need for a copilot on the SCAT. Laser and FLIR guidance and target acquisition systems will be augmented by helmet-mounted displays, with the helmet offering chemical, biological and laser protection. The T800-XX-800 turboshaft engine contracts have been awarded, and RFPs for development of the LHX prototypes will be issued in 1986. M.S.K.

**A86-10952#**

### POST-2000 - THE MULTIMODE AIRCRAFT SYSTEM

S. A. TREMAINE (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 6 p.
(AIAA PAPER 85-4015)

The multimode aircraft system concept and its potential use are examined. Some of the requirements necessary for future weapons systems are described. These weapon systems will be specialized, complex, and expensive; therefore, the design of an inexpensive aeronautical system which can perform more than one specific, specialized mission is needed. Examples of aircraft which have been designed for growth and operational improvements are provided. The difficulty in designing a multimode system and the positive and negative aspects of the development of this system are discussed. Examples of aircraft designed for modularization are presented. I.F.

**A86-11602*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### FUTURE DIRECTIONS IN AEROPROPULSION TECHNOLOGY

N. T. SAUNDERS and A. J. GLASSMAN (NASA, Lewis Research Center, Cleveland, OH) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 3-22. Previously announced in STAR as N85-23685.

Future directions in aeropropulsion technology that have been identified in a series of studies recently sponsored by the U.S. Government are discussed. Advanced vehicle concepts that could become possible by the turn of the century are presented along with some of their projected capabilities. Key building-block propulsion technologies that will contribute to making these vehicle concepts a reality are discussed along with projections of their status by the year 2000. Some pertinent highlights of the NASA aeropropulsion program are included in the discussion. Author

**A86-11647#**

**THE HISTORY AND FORESEEABLE DEVELOPMENTS IN RECIPROCATING ENGINES FOR AIRCRAFT**

C. M. EHRESMAN (Purdue University, West Lafayette, IN) and R. L. SPENCER (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 408-412. refs

A review of engine development for aircraft is presented. The major advances incorporated into engine designs from 1903 to the present are described. A chart explaining engine performanace based on horse power, specific power, specific output, and specific fuel consumption is provided. The areas where further research is required, particularly in reducing fuel consumption and using alternative fuels, are examined and proposed designs are discussed. I.F.

**A86-11872**

**REPAIR OF AIR-COOLED TURBINE VANES OF HIGH-PERFORMANCE AIRCRAFT ENGINES - PROBLEMS AND EXPERIENCE**

P. BRAUNY, M. HAMMERSCHMIDT, and M. MALIK (Deutsche Lufthansa AG, Hamburg, West Germany) Materials Science and Technology (ISSN 0267-0836), vol. 1, Sept. 1985, p. 719-727. refs

Air-cooled turbine vanes made from nickel- and cobalt-base superalloys undergo distortion, cracking, burning, and material degradation in operation. The complex geometry of the parts and the compositional and microstructural heterogeneity of cast alloys impose limitations on the selection of repair methods. Selective chemical stripping of the diffusion coatings; elimination of cracks and restoration of dimensions by joining processes involving both welding and brazing techniques; and formation of coatings by pack cementation are the major processes employed. These processes may give rise to defects that significantly diminish the integrity of the parts. Author

**A86-12290**

**HUMAN-POWERED FLIGHT**

M. DRELA (Institute for Defense Analyses, Alexandria, VA) and J. S. LANGFORD Scientific American (ISSN 0036-8733), vol. 253, Nov. 1985, p. 144-151.

For many centuries, people have dreamed of human flight. These dreams were concerned with flight in which the flier would provide the power, as a bird does. Yet only in the past 25 years has a human-powered aircraft been developed. In 1977, a prize related to the achievement of human-powered flight was finally won by flying the Gossamer Condor around a one-mile, figure-eight course exclusively under human power. In June 1979, a similar aircraft was pedaled across the English Channel. Details concerning three generations of human-powered aircraft are discussed along with the special characteristics which distinguish aircraft for human-powered flight from other aircraft. Attention is also given to a utilization of the technology, developed for human-powered aircraft, in other application areas. G.R.

**N86-10001#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ACTA AERONAUTICA ET ASTRONAUTICA SINICA (SELECTED ARTICLES)**

4 Oct. 1984 64 p refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 4, 1983 p 1-19, 11-19; 39-47; 101-104
(AD-A147304; FTD-ID(RS)T-1120-84) Avail: NTIS HC A04/MF A01 CSCL 01B

Research in aeronautics and astronautics in China is discussed. Some areas of research are: (1) approximation method for transonic flow over swept wings; (2) shock turbulent interaction over a compression corner for supersonic flow; (3) optimum design of an aircraft wing; and (4) a simple estimation method for two phase flow in a nozzle of rocket ramjet engine.

**N86-10006#** Information Spectrum, Inc., Arlington, Va.

**F-16X MSIP (MULTI-NATIONAL STAGED IMPROVEMENT PROGRAM) CASE EXAMPLE: OPERATING AND SUPPORT COST ESTIMATION USING VAMOSC (VISIBILITY AND MANAGEMENT OF OPERATING AND SUPPORT COSTS) Final Technical Report**

W. C. REDEEN 17 Aug. 1984 71 p
(Contract F33600-82-C-0543)
(AD-A156893; ISI-V-4859-02) Avail: NTIS HC A04/MF A01 CSCL 05A

This case example of a hypothetical F-16X MSIP (Multi-National Staged Improvement Program) Operating and Support (O&S) cost estimate, sponsored by AFLC/MM (VAMOSC), has been prepared to demonstrate and test the capability of the Air Force Visibility and Management of Operating and Support Costs (VAMOSC) system to provide unique and detailed experience data suitable for credible and explicit O&S cost estimation for advanced Air Force aircraft systems and subsystems. The specific objective of this effort is: To produce a case example of VAMOSC applicability to O&S cost estimation which conforms to the following conditions: Is compatible with OSD/CAIG and USAF costing guidance. Is linkable to reported experience data for existing aircraft. Provided a VAMOSC-Supported Methodology which can be utilized to predict the impact of configuration changes on system O&S costs. Depicts a methodology which is applicable to O&S costing for any aircraft system in advanced conceptual development. Provides estimates which are verifiable by tests. Identifies areas of VAMOSC requiring enhancement or modification to improve system integrity and applicability. GRA

**N86-10007#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THREE ARTICLES ON NEW CALCULATION METHODS IN AERONAUTICS (SELECTED ARTICLES)**

17 Aug. 1984 55 p refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 3, Sep. 1983 p 1-18, 56-62, and 102-104
(AD-A145745; FTD-ID(RS)T-0910-84) Avail: NTIS HC A04/MF A01 CSCL 01B

Selected research topics are investigated in search of new calculation methods for aeronautics. Numerical solutions are sought for calculating hypersonic flow and unsteady supersonic aerodynamic forces. Methods for determining aerodynamic coefficients are discussed. Selected highlights of the third conference of the Aeronautical Society of China are also discussed. Shear layer effects on the stability of an axisymmetrical external compression air intake are investigated.

**N86-11147#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**AERODYNAMICS AND ACOUSTICS OF PROPELLERS**

Loughton, England Feb. 1985 456 p refs In ENGLISH and FRENCH Symp. held in Toronto, 1-4 Oct. 1984
(AGARD-CP-366; ISBN-92-835-0374-0) Avail: NTIS HC A20/MF A01

A state of the art review of the aerodynamic design and testing of modern propellers, acoustic and vibration environmental problems and their solutions, and considerations in the integration of the propeller(s) and airframe is presented. Propellers have recently become a focus of attention after having been neglected for many years. The efficient use of propellers as a propulsion medium up to Mach 0.6 was realized at the expense of high noise and vibration. Since the mid-1970s there have been many developments, including the propfan, with an aerodynamic efficiency of 80% at Mach 0.8 now seriously challenges the fanjet. The advent of the supercritical airfoil is another significant development beginning to influence propeller design.

## 01 AERONAUTICS (GENERAL)

**N86-11178#** Joint Publications Research Service, Arlington, Va.
**DEPUTY MINISTER ON SECTOR'S TECHNICAL PROGRESS**
I. Y. MASHKIVSKIY *In its* USSR Rept.: Transportation (JPRS-UTR-85-011) p 1-6 7 Oct. 1985 Transl. into ENGLISH from Grazhdanskaya Aviats. (Moscow), no. 4, Apr. 1985 p 2-3
Avail: NTIS HC A06

Measures to accelerate the U.S.S.R.'s scientific and technical progress in the area of civil aviation are discussed. The development of more economical and efficient modifications of airplanes, helicopters, and engines to replace outdated models is described. The increased use of automated diagnostic equipment for aircraft maintenace is highlighted. B.W.

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-10021#**
**SUPERSONIC WIND TUNNEL SIMULATION OF PROPULSIVE JETS**
R. A. WHITE (Illinois, University, Urbana), J. AGRELL (Flygtekniska Forsoksanstalten, Bromma, Sweden), and S.-E. NYBERG Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, Sept.-Oct. 1985, p. 530-535. Research supported by the Flygtekniska Forsoksanstalten. refs
(Contract DAJA37-81-C-1213; DAAG29-79-C-0184)

This paper describes improvements in a modeling methodology for congruent plumes produced from nonideal nozzle flows and a series of verification tests including complex afterbody and wake flows caused by angle of attack and afterbody-mounted control fins at incidence. The results show that the modeling methodology gives good agreement for the base pressure and separation location for stagnation pressure ratios of + or 25 percent from the design condition, for angles of attack as high as + or - 20 deg, and with the effects of control fins deflected + or - 10 deg in conjunction with angle of attack of + or - 6 deg. A small but systematic difference between the prototype and model results is evident, and a possible explanation is offered. Author

**A86-10268*** George Washington Univ., Washington, D.C.
**COMPARISON OF UNIFORM PERTURBATION AND NUMERICAL SOLUTIONS FOR SOME POTENTIAL FLOWS PAST SLENDER BODIES**
T.-C. WONG (George Washington University, Washington, DC), C. H. LIU (NASA, Langley Research Center, Hampton, VA), and J. GEER (New York, State University, Binghamton) Computers and Fluids (ISSN 0045-7930), vol. 13, no. 3, 1985, p. 271-283. Previously announced in STAR as N85-14799. refs
(Contract NAS1-14605; NAS1-17070)

Approximate solutions for potential flow past an axisymmetric slender body and past a thin airfoil are calculated using a uniform perturbation method and then compared with either the exact analytical solution or the solution obtained using a purely numerical method. The perturbation method is based upon a representation of the disturbance flow as the superposition of singularities distributed entirely within the body, while the numerical (panel) method is based upon a distribution of singularities on the surface of the body. It is found that the perturbation method provides very good results for small values of the slenderness ratio and for small angles of attack. Moreover, for comparable accuracy, the perturbation method is simpler to implement, requires less computer memory, and generally uses less computation time than the panel method. In particular, the uniform perturbation method yields good resolution near the regions of the leading and trailing edges where other methods fail or require special attention. Author

**A86-10269*** Grumman Aerospace Corp., Bethpage, N.Y.
**SOLUTION OF VISCOUS TRANSONIC FLOW OVER WINGS**
R. R. CHOW (Grumman Aerospace Corp., Bethpage, NY) Computers and Fluids (ISSN 0045-7930), vol. 13, no. 3, 1985, p. 285-317. refs
(Contract NAS1-16858)

Since the calculations of plane steady transonic flows conducted by Murman and Cole (1971), steady progress has been made with respect to the computation of inviscid transonic flows. It has been found that it is inadequate to consider practical wing design at transonic speeds without considering the effects of viscosity and turbulence. The present study has the objective to develop a zonal method for viscous transonic flow over three-dimensional (3-D) wings. The employed approach follows closely the viscous/inviscid interaction techniques discussed by Melnik et al. (1983) for viscous flow about airfoils. Attention is given to inviscid flow equations and boundary conditions, the solution of 3-D boundary layer and wake, an iterative solution to viscid-inviscid interaction analysis, and results obtained for a transonic cruise wing of transport type. G.R.

**A86-10270**
**SHOCK FITTING IN CONICAL SUPERSONIC FULL POTENTIAL FLOWS**
M. J. SICLARI (Grumman Aerospace Corp., Bethpage, NY) and M. VISICH Computers and Fluids (ISSN 0045-7930), vol. 13, no. 3, 1985, p. 319-335. refs

The full potential equation is solved implicitly for supersonic conical flows with the bow shock fitted as an external boundary. Existing potential flow computational procedures capture the embedded crossflow shock within the context of transonic relaxation schemes. In this study, the crossflow shock is fitted for the first time in potential flow as an internal boundary. Hence, all shocks are implicitly fit making the computation fully conservative. For thin elliptic cones, the outer segment of the crossflow shock was found to be oblique to the incoming or supersonic crossflow. This behavior was not found for circular cones. The shock fitted solutions are compared to both Euler and potential captured solutions. The full potential shock fitted results are in favorable agreement with conservative captured solutions. Author

**A86-10271**
**ENTROPY CORRECTIONS TO SUPERSONIC CONICAL NONLINEAR POTENTIAL FLOWS**
M. J. SICLARI and A. RUBEL (Grumman Aerospace Corp., Bethpage, NY) Computers and Fluids (ISSN 0045-7930), vol. 13, no. 3, 1985, p. 337-359. refs

Entropy corrections are applied to full potential supersonic conical flows that have the bow shock fit as a boundary. The entropy corrections require the implementation of the Rankine-Hugoniot shock relations instead of the isentropic shock conditions. In addition, the pressure must be corrected to account for the bow shock induced entropy variation. For high Mach number and/or large deflection angles, the correction to the potential pressures can be of the same order of magnitude as the Euler pressures. Considering the simplistic nature of the corrections, remarkably accurate results are achieved for circular and elliptic cones. Additional corrections account for embedded crossflow shocks. Author

**A86-10363**
**AN EXPERIMENTAL INVESTIGATION INTO THE EFFECTS OF MODIFYING THE TRAILING EDGE GEOMETRY OF A WORTMANN FX63-137 AEROFOIL**
P. M. RENDER (Cranfield Institute of Technology, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 15.1-15.13. Research supported by the Ministry of Defence (Procurement Executive).

Wind tunnel tests were carried out to study the effects of modified trailing edge geometry on the aerodynamics of a number of FX63-137 airfoil configurations corresponding to Reynolds numbers in the range 300,000-1,000,000. One particular airfoil, the Goettingen 797, showed reduced laminar separation due to its flat lower surface configuration. A total of four alternative trailing edges having reduced undercamber and increased trailing edge thickness were tested in addition to the Goettingen airfoil. It is shown that modification of the thin trailing edge and undercamber of FX63-137 incurred only slight penalties in aerodynamic performance and actually led to improvements in the lift/drag ratio. Pressure measurements for the FX63-137 and the modified airfoil sections are provided. I.H.

**A86-10480#**

**STUDY ON DESIGN OF A SUPERSONIC NOZZLE. I - IMPROVEMENT OF A CALCULATING METHOD FOR A FLOWFIELD OF MIXED TYPE**

K. SETO, M. MATSUOKA (Saga University, Japan), and O. FUKUOKA (KYOCERA, Ltd., Kokubu, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, July 1985, p. 1396-1400. refs

The flowfield inside a nozzle is analyzed under both upstream and downstream boundary conditions using a series expansion procedure of the velocity components. The analysis is confined to the two-dimensional case. The results are consistent with those from other authors and from experiment. C.D.

**A86-10517#**

**EFFECT OF HINGE GAP ON AERODYNAMICS OF THIN AIRFOILS HAVING AN OSCILLATING FLAP**

S. ANDO (Nagoya University, Japan) and D.-H. LEE (Ulsan Institute of Technology, Republic of Korea) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 52, Sept. 1985, p. 712-717. refs

Nonsteady load distributions on a thin airfoil in inviscid incompressible flow having an oscillating flap with a narrow hinge gap are investigated. The angle of attack is assumed to be zero in front of the hinge gap. The problem is first attacked numerically through Poisson's integral equation to compare it with analytical methods derived later. The logarithmic singularity in the kernal function is treated with special care. Secondly the method of matched asymptotic expansions is used to analyze the problem. It brings forth simple closed-form expressions. Comparisons of results of the two methods show excellent agreement with each other, when gap width-to-chord ratio is less than 0.1. In addition, a simplified method is presented where no inner solution needs to be considered. It is useful for the gap/chord ratio less than 0.01. Author

**A86-10658**

**THEORY OF LOCAL INTERACTION IN A RAREFIED GAS - VARIANT OF THE METHOD OF TANGENT CONES [TEORIIA LOKAL'NOGO VZAIMODEISTVIIA V RAZREZHENNOM GAZE VARIANT METODA KASATEL'NYKH KONUSOV]**

R. N. MIROSHIN Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), July 1985, p. 103-105. In Russian. refs

The aerodynamic coefficients of the frontal drag and lift of an arbitrary convex body of revolution are represented through the corresponding coefficients for sharp cones tangent to the body and having a common axis of rotation with the body. This shows that the theory of the hypersonic-aerodynamic theory of local interaction in a rarefied gas is a variant of the method of tangent cones. B.J.

**A86-10729**

**BOUNDED FLOW PAST A SUPERCAVITATING FINITE-SPAN WING [OB OBTEKANII SUPERKAVITIRUIUSHCHEGO KRYLA KONECHNOGO RASMAKHA OGRANICHENNYM POTOKOM]**

M. V. MAKASEEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1985, p. 64-68. In Russian. refs

The problem of bounded flow past a supercavitating finite-span wing is treated numerically using the nonlinear programming approach. The numerical method proposed here makes it possible to calculate the flow from the specified cavitation number and can be easily extended to a wide class of linear supercavitation problems that involve solving integral equations. The method is sufficiently general and accurate to be used in engineering calculations and can be readily implemented in software. V.L.

**A86-10735**

**NONSYMMETRIC SOLUTIONS IN THE PROBLEM OF FLOW PAST A PLATE WITH A PAIR OF VORTEX-SINK COMBINATIONS [NESIMMETRICHNYE RESHENIIA V ZADACHE OBTEKANIIA PLASTINKI S PAROI VIKHRESTOKOV]**

M. G. GOMAN and A. N. KHRABROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1985, p. 181-183. In Russian. refs

Stationary flow past a plate with a pair of free attached vortex-sink combinations is analyzed for the case of normal flow incidence. The resulting flow pattern approximately corresponds to cross-section flow in the case of separated flow past a low-aspect-ratio wing at large angles of attack. It is shown that for some values of the sink intensity, solutions with a nonsymmetric arrangement of vortex-sink combinations exist along with symmetric solutions. V.L.

**A86-10933#**

**INTEGRATED FLOWFIELD ANALYSIS METHODOLOGY FOR FIGHTER INLETS**

R. R. COSNER (McDonnell Aircraft Co., St. Louis, MO) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs

(AIAA PAPER 85-3071)

A methodology has been developed to predict viscous flow over integrated fighter forebody-inlet combinations. It includes the effects of Mach number, Reynolds number, angle of attack, and engine mass flow. The analysis is based on a relaxation solution to the steady state Navier-Stokes equations, executed on a multiple-zone mesh. The solution [illegible] are affordable; the procedure can be executed on VAX-[illegible]80 computers. In this paper, computed results are compared with wind tunnel data on two contemporary aircraft: the F/A-18A and the AV-8B. Author

**A86-10934#**

**SUBSONIC DIFFUSER DESIGN AND PERFORMANCE FOR ADVANCED FIGHTER AIRCRAFT**

C. C. LEE (McDonnell Aircraft Co., St. Louis, MO) and C. BOEDICKER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs

(Contract F33615-82-C-3018)

(AIAA PAPER 85-3073)

McDonnell Aircraft Company (MCAIR), in conjunction with the Air Force, is conducting a study entitled 'Subsonic Diffusers For Highly Survivable Aircraft' to develop a methodology for designing short, highly offset, subsonic diffusers. The design concepts were selected and refined through analytical and experimental investigations. Test results indicate that compact diffusers can be made to yield acceptable performance by proper duct shaping and boundary layer bleed. Author

**A86-10939#**

**NOISE FROM A CIRCULATION CONTROL WING WITH UPPER SURFACE BLOWING**

M. SALIKUDDIN, W. H. BROWN, and K. K. AHUJA (Lockheed-Georgia Co., Marietta) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. Research supported by Lockheed Independent Research and Development Program. refs

(AIAA PAPER 85-3083)

The work presented in this paper represents a first step in understanding and evaluating the noise characteristics of a circulation control wing with upper surface blowing (CCW/USB). It was found that high frequency noise was dominated by the effects of the circulation control jet and that low frequency noise was dominated by the effects of the upper surface blowing. The individual effects of the CCW and the USB can be superimposed to yield a good approximation of the resultant effect in a combined CCW/USB configuration. Author

**A86-10940#**

**MAXIMUM CIRCULATION LIFT COEFFICIENT DEVELOPED ON A LOW ASPECT RATIO WING WITH A BLOWN FLAP**

V. R. STEWART (Rockwell International Corp., Columbus, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-3085)

The maximum circulation lift coefficient attainable on a low aspect ratio wing is discussed by comparing test results to various theoretical studies. Several theoretical predictions have been made of the maximum circulation lift coefficient. The predicted values have ranged from 1.2 times the wing aspect ratio to 1.94 times the aspect ratio. This paper briefly examines these studies and compares the results to test data. Available data from a recent test of a low aspect ratio propulsive wing/fuselage which included surface pressure instrumentation in addition to force balance measurements are analyzed to support the conclusions. Comparisons of the force and pressure data are explored to aid in the understanding of the factors limiting the circulation lift. The test results indicate that maximum circulation lift coefficients of approximately 1.9 times the aspect ratio have been obtained on the propulsive wing configuration. Author

**A86-10965#**

**LASER DOPPLER VELOCIMETER MEASUREMENTS IN A 3-D IMPINGING TWIN-JET FOUNTAIN FLOW**

K. R. SARIPALLI (McDonnell Douglas Research Laboratories, St. Louis, MO) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 14 p. Research sponsored by the McDonnell Douglas Independent Research and Development Program. refs
(AIAA PAPER 85-4036)

Mean velocity and turbulence measurements were conducted on the three-dimensional fountain flow-field generated by the impingement of two axisymmetric jets on a ground plane with application to vertical-take-off and landing (VTOL) aircraft. The basic instantaneous velocity data were obtained using a two-component laser Doppler velocimeter in a plane connecting the nozzle centerlines at different heights above the ground emphasizing the jet impingement region and the fountain upwash region formed by the collision of the wall jets. The distributions of mean velocity components and turbulence quantities, including the turbulence intensity and the Reynolds shear stress, were derived from the basic velocity data. Detailed studies of the characteristics of the fountain revealed self-similarity in the mean velocity and turbulence profiles across the fountain. The spread and mean velocity decay characteristics of the fountain were established. Turbulence intensities of the order of 50 percent were observed in the fountain. Author

**A86-11026#**

**ANALYSIS OF LEADING-EDGE VORTICES ON COMPLEX CONFIGURATIONS**

J. K. NATHMAN (Analytical Methods, Inc., Redmond, WA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-4054)

This paper describes the theory and application of VORSEP, a wake synthesizer for panel methods that use an iterative procedure to determine the position of strongly interacting vortex sheets. The estimation of the wake geometry is based on slender body theory with separation. An unsteady, two-dimensional airfoil program was automated with the addition of routines to interpolate cross-sectional geometry from arbitrary three-dimensional bodies, generate multi-core wakes and synthesize a three-dimensional wake structure. The method is applied to the leading-edge separation on delta and double-delta wings, the strake vortex of an STOL fighter, and the A-pillar separation on an automobile. Comparison with experimental data show results with the estimated wakes are physically more realistic than attached flow calculations and would be a suitable starting point for a three-dimensional iterative solution. In some cases, no improvement in the solution is required. Author

**A86-11027*#** North Carolina State Univ., Raleigh.

**AN EXPERIMENTAL INVESTIGATION OF APEX FENCE FLAPS ON DELTA WINGS**

R. J. VESS (North Carolina State University, Raleigh), R. A. WAHLS, and C. A. MOSKOVITZ AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(Contract NCC1-46)
(AIAA PAPER 85-4055)

The effects on leading edge vortex formation produced by apex fences mounted on two delta wings were examined in a subsonic wind tunnel. Pressure data were collected on the upper surface of the test wings and oil flow and bubble flow visualizations were performed. The deflections studied were 74, 90 and 65 deg in one-sided and two-sided configurations. Full span and semi-span delta wing planforms were used. Relatively small, symmetrically deployed apex fences provided enhanced upper surface suction which, in some angle-of-attack situations, could lead to a pitch-up force. Asymmetrically-deployed fences showed promise for yaw control at high angles of attack, althouh the force effectiveness has yet to be quantified. M.S.K.

**A86-11028#**

**A UNIQUE APPLIED COMPUTATIONAL METHOD FOR VORTEX LIFT AERODYNAMICS AND VORTEX BURST FOR ARBITRARY AIRCRAFT**

C. J. DIXON and G. T. DRISKILL (Lockheed-Georgia Co., Marietta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 19 p. refs
(AIAA PAPER 85-4057)

This paper describes a unique method to predict the aerodynamic forces on a variety of aircraft configurations employing leading edge vortex lift. A rigorous two-dimensional solution of a combined free leading edge vortex and sink on a flat plate airfoil has been combined with a three-dimensional vortex lattice method to predict the loads and moments on the configuration and the boundary conditions for the free vortex. With these boundary conditions, the analysis includes the effects of transition of the vortex core from laminar to turbulent and subsequent burst. Two breakdown criteria are required to analyze configurations with a wide range of leading edge sweep. Reynolds number is shown to have large effects at the low values typical of smoke tunnels and water channels. Experimental data are compared with theory, showing excellent agreement prior to vortex breakdown and good agreement after breakdown. Author

**A86-11029#**

**AN EFFICIENT METHOD FOR COMPUTING UNSTEADY TRANSONIC AERODYNAMICS OF SWEPT WINGS WITH CONTROL SURFACES**

D. D. LIU (Arizona State University, Tempe), K. Y. FUNG (Arizona, University, Tucson), and Y. F. KAO AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 17 p. Navy-supported research. refs
(AIAA PAPER 85-4058)

A transonic equivalent strip (TES) method has been further developed for unsteady flow computations of arbitrary wing planforms. The TES method consists of two consecutive correction steps to a given nonlinear code such as LTRAN2; namely, the chordwise mean-flow correction and the spanwise phase correction. The computation procedure requires direct pressure input from other computed or measured data. Otherwise, it does not require airfoil shape or grid-generation for given planforms. To validate the computed results, four swept, tapered wings of various aspect ratios, including those with control surfaces, are selected as computational examples. Overall trends in unsteady pressures are established with those obtained by XTRAN3S codes, Isogai's full potential code and measured data by NLR and RAE. In comparison with these methods, the TES has achieved considerable saving in computer time and reasonable accuracy which suggests immediate industrial applications. Author

**A86-11030#**

### SUBSONIC/SUPERSONIC LINEAR UNSTEADY ANALYSIS

W. CLEVER (Rockwell International Corp., Los Angeles, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 12 p.
(AIAA PAPER 85-4059)

Using an expansion in powers of reduced frequency, a linearized unsteady panel formulation is developed which is valid for both subsonic and supersonic Mach numbers. With this formulation a numerical pilot code was developed, using chord plane singularities, to analyze relatively general three-dimensional geometries for a wide range of oscillation frequencies. A constant value of unsteady Delta Cp across each panel eliminates the problem of singularities associated with control points near Mach cones emanating from panel corners, and from singularities associated with panels having sonic edges. Results from the computations indicate good agreement with a doublet lattice analysis at subsonic Mach numbers, for a nonplanar oblique wing configuration, and with an exact solution at supersonic speeds for a 60 degree delta wing. All integrations are done exactly in closed form and the technique may be expanded to more general panels of the Pan-Air type. Author

**A86-11031#**

### FULL POTENTIAL AND EULER SOLUTIONS FOR THE UNSTEADY TRANSONIC FLOW PAST A FIGHTER WING

L. N. SANKAR (Georgia Institute of Technology, Atlanta), J. B. MALONE, and D. SCHUSTER (Lockheed-Georgia Co., Marietta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 13 p. Research supported by the Lockheed-Georgia Independent Research and Development Program. refs
(AIAA PAPER 85-4061)

The problem of steady and unsteady transonic flow over modern fighter wing configurations has been addressed using two solution procedures. In the first procedure, the three-dimensional unsteady full potential equation is solved in a body-fitted coordinate system using a Strongly Implicit Procedure (SIP). In the second approach, the unsteady Euler equations are solved using a stable, hybrid numerical scheme. A number of steady and unsteady calculations are presented for a F-5 fighter wing configuration and compared with experiments. Author

**A86-11032#**

### UNSTEADY FULL POTENTIAL CALCULATIONS FOR COMPLEX WING-BODY CONFIGURATIONS

J. B. MALONE (Lockheed-Georgia Co., Marietta) and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 15 p. refs
(AIAA PAPER 85-4062)

A solution procedure is described for solving the unsteady transonic full potential equation for wing-body configurations undergoing arbitrary motions. This procedure is an extension of a previously published solution technique for unsteady transonic flow past wing-alone configurations. Numerical results are presented for a variety of configurations in both steady and unsteady subsonic and transonic flow conditions. Where possible, the theoretical predictions are compared with experimental data. Author

**A86-11033#**

### AERODYNAMIC BUGS - CAN CFD SPRAY THEM AWAY?

R. S. SHEVELL (Stanford University, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs
(AIAA PAPER 85-4067)

The potential for CFD techniques for eliminating aerodynamic problems in the design stage of subsonic transport aircraft is assessed. Conventional, non-CFD mathematical tools cannot accurately predict performance at stall speeds and high angles of attack, i.e., situations encountered at take-off, landing and shocked separated flow conditions. CFD allows the numerical study of previously inaccessible flight regimes, and rapid focusing on the individual effects surrounding external aircraft components. However, understanding of the fundamental flow physics will always be a cornerstone to applied aerodynamics, but is not necessarily a part of CFD, which is therefore a validation tool for designer calculations. Techniques for the fruitful interaction of the two methods are illustrated by tracing the evolution of the DC-8 airfoils to the DC-10 airfoils. M.S.K.

**A86-11037#**

### AERODYNAMIC TRADEOFF STUDY OF CONVENTIONAL, CANARD, AND TRI-SURFACE AIRCRAFT SYSTEMS

B. P. SELBERG and K. ROKHSAZ (Missouri-Rolla, University, Rolla) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-4071)

Conventional, canard, and three-surface aircraft configurations are investigated analytically to determine each configuation's induced and viscous drag under trimmed conditions. A three-surface vortex lattice method is used to trim the aircraft as well as to predict the induced drag of each configuration. A vortex panel method, in conjunction with a momentum integral boundary layer method, is used to predict inviscid and viscous characteristics. Parameters varied included wing to stabilator surface area ratio, static margin, canard to tail loading ratio, and total lift coefficient trim. For all parameters considered the conventional congiguration had the highest total lift coefficient trim/induced drag coefficient. At the lower stabilator aspect ratios the conventional's total lift coefficient trim/total drag coefficient was the highest whereas for the highest stabilator aspect ratio considered the canard configuration had the highest total lift coefficient trim/total drag coefficient. The tri-surface was superior to the canard at the lower aspect ratio, with the canard becoming superior at the higher values. Author

**A86-11038*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### IMPACT OF AIRFOIL PROFILE ON THE SUPERSONIC AERODYNAMICS OF DELTA WINGS

R. M. WOOD and D. S. MILLER (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 13 p. refs
(AIAA PAPER 85-4073)

A nonlinear flow model was employed to predict the flowfield, pressure and force data for delta wings at supersonic speeds. The goal of the study was to investigate the influence the airfoil profiles has on the wing aerodynamics. The analysis covers wing aspect ratios from 0.5-3.0 with leading edge sweep of 0.5-4.0 on diamond, circular arc and NACA modified 4-digit airfoils. Nonlinear aerodynamics are approximated with nonlinear zero-lift wave drag curves, yielding results significantly different from those obtained from linear calculations. The analyt[illegible] technique, useful in preliminary design studies, indicates in [illegible] cases that 90 percent of wave drag is generated at the wing apex and trailing edge. M.S.K.

**A86-11039*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### COMPUTATIONAL WING DESIGN IN SUPPORT OF AN NLF VARIABLE SWEEP TRANSITION FLIGHT EXPERIMENT

E. G. WAGGONER, R. L. CAMPBELL, and P. S. PHILLIPS (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-4074)

A natural laminar flow outer panel wing glove has been designed for a variable sweep fighter aircraft using state-of-the-art computational techniques. Testing of the design will yield wing pressure and boundary-layer data under actual flight conditions and environment. These data will be used to enhance the understanding of the interaction between crossflow and

Tollmien-Schlichting disturbances on boundary-layer transition. The outer wing panel was contoured such that a wide range of favorable pressure gradients could be obtained on the wing upper surface. Extensive computations were performed to support the design effort which relied on two- and three-dimensional transonic design and analysis techniques. A detailed description of the design procedure that evolved during this study is presented. Results on intermediate designs at various stages in the design process demonstrate how the various physical and aerodynamic constraints were integrated into the design. Final results of the glove design analyzed as part of the complete aircraft configuration with a full-potential wing/body analysis code indicate that the aerodynamic design objectives were met. Author

**A86-11040#**

### A DIRECT-INVERSE TRANSONIC WING DESIGN-ANALYSIS METHOD WITH VISCOUS INTERACTIONS

L. A. CARLSON (Texas A & M University, College Station) and R. A. WEED (Lockheed-Georgia Co., Marietta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. Research supported by the Texas A & M Research Foundation and Lockheed-Georgia Co. refs
(Contract N0167-81-C-0078-P00004)
(AIAA PAPER 85-4075)

A direct-inverse transonic wing design method which includes the effects of viscous interaction due to a turbulent boundary layer is presented. The method is based upon the fully conservative ZEBRA II transonic potential flow algorithm, uses a Cartesian-like grid system, and includes automatic relofting to control the amount of trailing edge thickness at each design station. Viscous interaction is included by a two-dimensional boundary layer scheme modified to account for the first order effects of three dimensionality. Comparisons with experimental data are presented which verify that this method improves transonic aerodynamic studies associated with preliminary design and analysis. Author

**A86-11041*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS

D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows. Author

**A86-11042#**

### EXPERIMENTAL VERIFICATION OF THREE-DIMENSIONAL TRANSONIC INVERSE METHOD

S. TATSUMI (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) and S. TAKANASHI (National Aerospace Laboratory, Tokyo, Japan) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-4077)

A three-dimensional transonic wing design method was developed for wing alone and wing-body combination. The method is based on an iterative 'residual-correction' concept combined with existing three-dimensional transonic full potential flow analysis code. Transonic swept wings with specified pressure distribution were designed for typical civil transports and wind tunnel tests were conducted to verify the usefulness of the method. The comparison in pressure distribution of experimental data with design targets show satisfactory agreements, suggesting that the method provides a practical and effective tool in aerodynamic design of aircraft wings. Author

**A86-11043#**

### NUMERICAL EXPERIMENT WITH INVISCID VORTEX-STRETCHED FLOW AROUND A CRANKED DELTA WING - SUBSONIC SPEED

A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) and C. J. PURCELL (ETA Systems, Inc., St. Paul, MN) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 12 p.
(AIAA PAPER 85-4080)

A numerical method that solves the Euler equations for compressible flow is used to study vortex stretching. The particular case simulated is subsonic flow with freestream M = 0.3 and alpha = 10 deg around the twisted and cambered cranked-and-cropped TKF delta wing of MBB. This geometry induces multiple leading-edge vortices in a straining velocity field that brings about flow instabilities but the result is a state of statistical equilibrium. The discretization contains over 600,000 cells and offers sufficient degrees of freedom in the solution to exhibit the onset of chaotic vortex flow that could well lead to turbulence. The simulated results are compared with wind-tunnel measurements. Author

**A86-11044#**

### FLOW-FIELD COMPUTATIONS AROUND NOZZLE/AFTERBODY CONFIGURATIONS AT TRANSONIC MACH NUMBERS

U. C. GOLDBERG, J. J. GORSKI, and S. R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 8 p. refs
(AIAA PAPER 85-4081)

The flow field around nozzle-afterbody configurations is computed using a finite volume code, incorporating a total variation diminishing implicit upwind biased scheme for high accuracy. Results are shown for two combinations of jet and freestream conditions, using the k-epsilon turbulence model, with a new near-wall treatment. Agreement with experimental data is very good. Author

**A86-11048#**

### OPTIMIZATION OF THREE-DIMENSIONAL COMPUTATIONAL GRIDS

R. CARCAILLET, S. R. KENNON, and G. S. DULIKRAVICH (Texas, University, Austin) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4087)

A method for generating and optimizing arbitrary three-dimensional boundary-conforming computational grids has been developed. The smoothness and local orthogonality of the grid are maximized using a fast iterative procedure, and provision is made for clustering the optimized grid in selected regions. An optimal grid can be obtained iteratively, irrespective of the method used to generate the initial grid. Unacceptable grids and even singular grids (i.e., grids containing regions of overlap) can be made useful for computation using this method. Application of the method to several test cases shows that grids containing regions of overlap are typically untangled in two to five iterations, and that the conjugate gradient optimization procedure converges to an optimal grid within fifty iterations. Taking advantage of the original properties of this method, a new concept for generating optimal three-dimensional computational grids is proposed. It consists in optimizing a first guess of the desired grid, using an imperfect grid generated by a simple, inexpensive method as input. Author

**A86-11049#**

**COMPUTATIONAL GRID GENERATION FOR REALISTIC AIRCRAFT CONFIGURATIONS**

D. M. SOMMERFIELD, G. S. DULIKRAVICH, and S. R. KENNON (Texas, University, Austin) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 8 p. refs
(AIAA PAPER 85-4089)

A computational technique is presented for transforming three-dimensional space into a series of two-dimensional planes for conformal mapping of flowfields around aircraft designs. The aircraft geometry is radially sheared to convert the fuselage into a circular cylinder. The lifting surfaces are thereby also radially sheared and stretched. The intersections between the computational surfaces and the distorted lifting surfaces are obtained by fitting spanwise cubic splines to chordwise locations using Newton's iteration scheme. The surfaces are unwrapped after the intersections are determined, yielding planar strips. Further computations identify the grid points for the planes, which can then be rewrapped around the physical space of interest. Sample results are provided for grids generated for the F-16 and NASA F-8 oblique wing aircraft. M.S.K.

**A86-11050#**

**AN INVESTIGATION OF GRIDDING ON THE ACCURACY OF FLO57MM AND FLO57MG EULER WING SOLUTIONS**

C. J. WOAN and E. BONNER (Rockwell International Corp., Computational Fluid Dynamics Group, Los Angeles, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 13 p. Research supported by the Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 85-4090)

The impact of gridding on the solution accuracy of Jameson's wing-alone Euler codes FLO57MM and FLO57MG was evaluated for the ONERA M6 wing at a Mach number of 0.84 for an angle of attack 3.06 degrees. Axial, vertical and lateral grid sizes of 66 x 16 x 16, 96 x 16 x 16, and 96 x 24 x 24 with various degrees of clustering in the three coordinate directions were considered. Details of grid generation and spacing are given. Experimental comparisons indicate the double shocks on the wing upper surface are accurately captured for the most dense grid with suitable grid clustering, and show substantial improvement over the previously published results. Author

**A86-11051#**

**COMPARISON OF RESULTS FROM A PANEL METHOD AND AN EULER CODE FOR A CRANKED DELTA WING**

L. FORNASIER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrun, West Germany) and A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs
(AIAA PAPER 85-4091)

A panel code and an Euler code are evaluated as prediction tools for simulating the flow around a cranked-delta wing configuration at Mach numbers equal to 0.30, 0.90, and 1.20. Comparisons are made for global longitudinal characteristics, spanwise variations of local aerodynamic coefficients, and surface pressures. Predictions from the two codes are in good agreement with experimental data at low angles of attack for all Mach numbers studied. At higher angles of attack, the panel code is unable to simulate the phenomena related to the development of a separated leading edge vortical flow and to the formation of large regions of supercritical flow at transonic speeds. The Euler code proved to be able to predict the essential features of such nonlinear effects, especially at 10 deg angle of attack. At intermediate values where the flow is in transition from linear to shed vortex flow, the Euler code seems to overpredict the nonlinear effect. C.D.

**A86-11052#**

**EVALUATION OF FOUR PANEL AERODYNAMIC PREDICTION METHODS (MCAERO, PAN AIR, QUADPAN, AND VSAERO)**

W. Z. STRANG, C. H. BERDAHL, E. L. NUTLEY, and A. J. MURN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 17 p. refs
(AIAA PAPER 85-4092)

Four linearized potential panel codes are compared using three test cases having datum solutions. The test cases are a simple wing, a straked-wing, and a nacelle. Each code predicts similar flow, but VSAERO and QUADPAN usually 'leak' more and predict lower section loading than PAN AIR and MCAERO. Execution times and user friendliness are compared. Although all four codes solve the linearized potential flow about a vehicle, each code has unique features which may influence a prospective user's choice of a code for flow analysis or vehicle design. Author

**A86-11054#**

**A TECHNIQUE FOR THE INVERSE AERODYNAMIC DESIGN OF NACELLES AND WING CONFIGURATIONS**

J. B. MALONE, J. VADYAK (Lockheed-Georgia Co., Marietta, GA), and L. N. SANKAR (Georgia Institute of Technology, Atlanta, GA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(AIAA PAPER 85-4096)

A semi-inverse design algorithm is presented which is based on the well-known Garabedian-McFadden procedure. The modified inverse algorithm permits the design of aerodynamic components with prescribed surface pressures. Details of the present design procedure are given and several examples illustrating the use of the design technique with existing aerodynamic analysis methods are discussed. Computed results for sample design problems are presented for 2-D airfoils, 2-D nacelle inlets, and 3-D nacelle configurations. Author

**A86-11055#**

**THE CONCEPT OF LATERAL BLOWING**

D. A. TAVELLA and L. ROBERTS (Stanford University, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-5000)

The concept of lateral blowing consists in utilizing thin jets of air, which are ejected in the spanwise direction from slots at the tips of straight or swept wings to generate aerodynamic forces without the assistance of deflecting solid surfaces. For weak intensities of blowing the so-generated forces could be used for roll and lateral control of aircraft. In this work a theory for this concept as applied to straight wings is presented, revealing the analytical relationship between blowing and aerodynamic forces. The approach is based on perturbing the span of an elliptically loaded wing. Scaling laws involving blowing intensity, aspect ratio, and angle of attack are derived and compared with experiments. It is concluded that this concept has potential as a novel roll and lateral control device. Author

**A86-11056#**

**INFLUENCE OF TIP BLOWING ON RECTANGULAR WINGS**

D. A. TAVELLA, N. J. WOOD, and P. HARRITS (Stanford University, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-5001)

The aerodynamics of a rectangular wing with a jet exhausting in the spanwise direction from the tips has been explored experimentally. By effectively changing the span of the wing as well as outwardly displacing the tip vortices, such jets can induce aerodynamic forces that could be used for roll and lateral control of aircraft. The concept has been investigated for a variety of jet intensities, aspect ratios and angles of attack. The results appear to confirm theoretically predicted scaling laws for lift and moment gains due to blowing. Author

**A86-11058#**

### FLOW SIMULATIONS FOR DETAILED NACELLE-EXHAUST FLOW USING EULER EQUATIONS

H. C. CHEN, K. KUSUNOSE, and N. J. YU (Boeing Commercial Airplane Co., Seattle, WA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 8 p. refs
(AIAA PAPER 85-5003)

A simulation method for the detailed analysis of nacelle exhaust flowfields based on Jameson et al. (1981) Euler technology has been presented. An axisymmetric code and a general three-dimensional (3-D) code have both been developed. The axisymmetric version is particularly useful for fundamental studies such as grid density requirements, whereas the 3-D version is particularly suited for real applications involving nonaxisymmetric geometry and angle-of-attack effects. The addition of one-plane-of-symmetry to the 3-D code enhances its usefulness by doubling the number of available grid points. Reasonable agreement has been obtained in test-theory comparison for both axisymmetric and 3-D cases. The analysis of a transport nacelle at high power setting reveals complex expansion-compression flow patterns in the exhaust flow region. Author

**A86-11059*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### TRANSONIC SEPARATED SOLUTIONS FOR AN AUGMENTOR-WING

J. FLORES and W. R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-5004)

The viscous transonic flow about a multielement airfoil (augmentor-wing) is simulated by coupling full-potential and direct/inverse differential boundary-layer algorithms. Solutions have been obtained for a variety of conditions and are in fair agreement with available experimental data. Typical results from this transonic augmentor-wing code (TAUG-V) require approximately three minutes of CRAY-XMP CPU time. Since this viscous transonic code accounts for most of the important flow physics, yet is still economical, it is a practical tool for the design aerodynamicist. Author

**A86-11060#**

### LEADING EDGE FLAP PLANFORM EFFECTS FOR WINGS OF MODERATE LEADING EDGE SWEEP

A. C. GRANTZ (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 18 p. refs
(AIAA PAPER 85-5005)

A low-speed wind tunnel investigation was conducted which addressed the effects of leading edge flap area, flap deflection, and flap hinge-line sweep for wings of moderate (40 to 55 degrees) leading edge sweep. Oil flow visualization photographs and VLM-SA comparisons were made for selected configurations. Leading edge flaps of conventional taper were shown to provide higher L/D than flaps of constant chord and inverse taper planforms for wings with a leading edge sweep angle of 50 degrees. In all cases, the 14 and 17 percent area leading edge flaps yielded the best L/D performance at moderate to high lift coefficients independent of wing leading edge sweep angle. Despite the mixed, attached and vortical flowfields produced by the leading edge flaps investigated, the VLM-SA calculations agreed very well with the experimental drag polars. Author

**A86-11062#**

### SYMMETRIC SEPARATED FLOW PAST SLENDER BODIES AT ANGLES OF ATTACK IN SUBSONIC AND SUPERSONIC FLOWS

A. K. SREEKANTH (Indian Institute of Technology, Madras, India) and S. PANNEERSELVAM (Defence Research Development Laboratory, Hyderabad, India) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-5007)

A prediction method has been developed for determining the normal force and pitching moment on bodies of revolution both in subsonic and supersonic flows at angles of attack up to the onset of asymmetric vortex shedding. The analysis assumes that the force on the body is the sum of inviscid and viscous contributions. Woodward's three dimensional panel method is used for inviscid flow calculations. In the viscous analysis the contributions from the shed vortices and the feeding sheet are accounted for separately. Comparisons are made of the predicted values with available experimental data on a representative ogive cylinder body. Author

**A86-11063#**

### COMPARISON BETWEEN EXPERIMENTAL AND COMPUTATIONAL RESULTS FOR AIRFOILS EQUIPPED WITH A SPOILER AND A FLAP

M. COSTES (ONERA, Chatillon-sous-Bagneux, France) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 7 p. Research supported by the Service Technique des Programmes Aeronautiques and DRET.
(AIAA PAPER 85-5008)

A computer code including viscous effects by strong coupling is used to compute the steady flow around an airfoil equipped with a spoiler. Comparison with experimental data shows that the code is able to predict, at least qualitatively, the influence of aerodynamic and geometric parameters such as free stream Mach number. spoiler deflection, spoiler chord, spoiler position, trailing edge flap deflection, Reynolds number. Author

**A86-11065*#** Scientific Research Associates, Inc., Glastonbury, Conn.

### NUMERICAL STUDY OF THREE-DIMENSIONAL TURBULENT FLOW INTERACTIONS BETWEEN BLOCKAGE MODELS AND WIND TUNNELS INCLUDING LONGITUDINALLY SLOTTED TEST SECTIONS

S.-J. LIN and R. LEVY (Scientific Research Associates, Inc., Glastonbury, CT) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 14 p. refs
(Contract NAS3-24224)
(AIAA PAPER 85-5017)

A spatial forward-marching approach is applied to compute three-dimensional turbulent flows for several blockage models in free flight, in a solid wall wind tunnel, and in a wind tunnel with longitudinal slots in the test section. The effects of area blockage in the tunnel, model growth and tunnel wall boundary layers, and of the slots are included. The large blockage models are found to have significant wall interference effects which can be reduced by the slots. The effects of the latter are confined to the region near the tunnel wall. Model/wall interference effects are not limited to the effects of area blockage; in particular, boundary layer profile shapes for a wind tunnel model in a tunnel are different from shapes for a model in free flight even when slots are used. This indicates that the flow responds differently in these two cases with the same pressure gradient. C.D.

**A86-11066#**

### COMPUTATIONAL ESTIMATIONS OF STRUT SUPPORT INTERFERENCE AT TRANSONIC MACH NUMBERS

N. E. SUHS (Calspan Corp., Arnold Air Force Station, TN) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 7 p. refs
(AIAA PAPER 85-5018)

A computational method is presented that numerically quantifies the interference of model support struts in transonic wind tunnel tests. The method solves the three-dimensional Euler equations for a wing/body/strut model configuration in a typical wind tunnel installation. Computations and measurements are in good agreement over the range of transonic Mach numbers. Author

**A86-11067#**

### APPLICATION OF EXPERIMENTAL AND THEORETICAL METHODS TO VALIDATE RESULTS OBTAINED ON AN ISOLATED INLET COWL WIND TUNNEL TEST RIG

E. C. CARTER and W. HIRST (Aircraft Research Association, Ltd., Bedford, England) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(AIAA PAPER 85-5019)

Recent analysis of results obtained on a cowl inlet test rig in a transonic test section indicated some doubt over the standard corrections to free stream Mach number which were used to allow for the effects of rig blockage and interference. Investigative tests of tunnel flow have been made and these results, together with correlations with current theory have indicated that early interference corrections to M have been underestimated. This paper describes the steps in the investigation, the justification for the new correction terms and the reasons for the original errors. The work shows how the development of improved CFD methods can be incorporated with experimental data to improve the quality of tests. Author

**A86-11068#**

### ESTIMATING WATER VAPOR CONDENSATION EFFECTS FOR TRANSONIC AND SUPERSONIC FLOW FIELDS

C. E. ROBINSON, R. C. BAUER (Calspan Corp., Arnold Air Force Station, TN), and R. H. NICHOLS (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 8 p. refs
(AIAA PAPER 85-5020)

A computer code has been developed which estimates the effect of water vapor condensation on flow fields using the Euler equations. The program computes the effect by including the energy release attributable to condensation in the energy equation. In this manner, the local effect of condensation is included in the calculation of the flow-field properties. A species equation for the conservation of water vapor is also included as well as an empirical method of predicting the onset of condensation. To evaluate the effectiveness of the code, calculations of the transonic flow field about a two-dimensional airfoil and the flow in two planar two-dimensional supersonic nozzles have been made at discrete values of specific humidity. The effects of local condensation estimated by the code are in good agreement with the experimental data found in the literature for nozzle flows. Author

**A86-11070*#** Colorado Univ., Boulder.

### NUMERICAL SIMULATION OF TRANSONIC FLOW OVER POROUS AIRFOILS

C.-Y. CHOW (Colorado, University, Boulder, CO), T. L. HOLST, W. R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA), and C.-L. CHEN AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. Previously announced in STAR as N85-27828. refs
(Contract NCC2-355)
(AIAA PAPER 85-5022)

A numerical study was made to examine the effect of a porous surface on the aerodynamic performance of a transonic airfoil. The pressure jump across the normal shock wave on the upper surface of the airfoil was reduced by making the surface below the shock porous. The weakened shock is preceded by an oblique shock at the upstream end of the porous surface where air is blown out of the cavity. The lambda shock structure shown in the numerical result qualitatively agrees with that observed in the wind tunnel. According to the present analysis, the porous airfoil has a smaller drag and a higher lift than the solid airfoil. Author

**A86-11071#**

### COMPARISON OF TRANSONIC AIRFOIL CHARACTERISTICS BY NAVIER-STOKES COMPUTATION AND BY WIND TUNNEL TEST AT HIGH REYNOLDS NUMBER

J. MIYAKAWA (Mitsubishi Heavy Industries, Ltd., Aerodynamic Research Section, Nagoya, Japan), N. HIROSE, and N. KAWAI (National Aerospace Laboratory, Tokyo, Japan) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(AIAA PAPER 85-5025)

Two-dimensional Navier-Stokes code (NSFOIL) is validated in terms of analysis of practical transonic advanced technology airfoil compared to wind tunnel test. The comparison is carried out at high Reynolds number of 23 million which is corresponding to actual flight condition of a transonic transport aircraft. The agreements are satisfactory in both aerodynamic forces and pressure coefficients so that the code is concluded to be a very effective tool to predict non-linear characteristics of transonic airfoils, which has never been possible by any inviscid code. In the course of the careful comparison process, some future improvements of the code are probed in order to get even better simulation by this hopeful computer code. Author

**A86-11072#**

### THE USE OF NUMERICAL OPTIMIZATION FOR AIRFOIL DESIGN

J. RENEAUX and J.-J. THIBERT (ONERA, Chatillon-sous-Bagneux, France) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-5026)

The paper describes an airfoil design method based on numerical optimization techniques. This method allows the design of airfoils with certain aerodynamic objectives and with respect to geometric or aerodynamic constraints. After a presentation of the method, the paper describes different applications. Airfoil design processes for ultralight aircraft, for propeller and helicopter blades and for shrouded tail rotor are explained and the performances of these airfoils are given. The new airfoils designed using this method perform better than other known airfoils which demonstrates the efficiency of the numerical optimization technique. In conclusion, some remarks concerning the disadvantages of the method are presented as well as its possible use for other aerodynamic applications. Author

**A86-11073#**

### THE SEPARATED AND NON-SEPARATED AIRFOIL WAKE BEHAVIOR IN THE PRESENCE OF FREE STREAM TURBULENCE

M. ARDEBILI, B. K. HAZARIKA, and R. RAJ (City College, New York) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs
(AIAA PAPER 85-5027)

The wake of a cambered airfoil was measured at three angles of attack and at two free stream turbulence levels. At high angle of attack and low free stream turbulence level a separation bubble was observed on the airfoil surface. Separation bubble was removed with the increase of free stream turbulence and the results were compared. The experimental results obtained were also empirically correlated for predicting the mean wake properties. Author

**A86-11096*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AERODYNAMIC INTERACTION BETWEEN VORTICAL WAKES AND THE VISCOUS FLOW ABOUT A CIRCULAR CYLINDER**

P. M. STREMEL (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 19 p. refs
(AIAA PAPER 85-4063)

In the design analysis of conventional aircraft configurations, the prediction of the strong interaction between vortical wakes and the viscous flow field about bodies is of considerable importance. Interactions between vortical wakes and aircraft components are even more common on rotorcraft and configurations with lifting surfaces forward of the wing. An accurate analysis of the vortex-wake interaction with aircraft components is needed for the optimization of the payload and the reduction of vibratory loads. However, the three-dimensional flow field beneath the rotor disk and the interaction of the rotor wake with solid bodies in the flow field are highly complex. The present paper has the objective to provide a basis for the considered interactions by studying a simpler problem. This problem involves the two-dimensional interaction of external wakes with the viscous flow about a circular cylinder. G.R.

**A86-11157*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LIFTING SURFACE THEORY FOR A HELICOPTER ROTOR IN FORWARD FLIGHT**

H. TAI (NASA, Langley Research Center, Hampton, VA) and H. L. RUNYAN (College of William and Mary, Hampton, VA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 11 p. Previously announced in STAR as N85-10916. refs

A lifting surface theory was developed for a helicopter rotor in forward flight for compressible and incompressible flow. The method utilizes the concept of the linearized acceleration potential and makes use of the vortex lattice procedure. Calculations demonstrating the application of the method are given in terms of the lift distribution on a single rotor, a two-bladed rotor, and a rotor with swept-forward and swept-back tips. In addition, the lift on a rotor which is vibrating in a pitching mode at 4/rev is given. Compressibility effects and interference effects for a two-bladed rotor are discussed. Author

**A86-11226#**

**AIRFOIL DYNAMIC STALL PERFORMANCE WITH LARGE-AMPLITUDE MOTIONS**

M. S. FRANCIS and J. E. KEESEE (USAF, Office of Scientific Research, Washington, DC) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1653-1659. refs
(Contract AF PROJECT 2307; AF TASK F1)

Dynamic lift levels approaching three times the corresponding quasisteady maximum values have been observed to occur and sustain to very high incidence angles (60 deg) when airfoils undergo rapid, large-amplitude pitchup motions at constant rate. Measurements of unsteady surface pressure distributions on two different airfoil shapes have captured the footprint of an energetic separation vortex which originates at the leading edge and exerts a substantial influence on the loading history as it convects downstream. To evaluate the potential of exploiting lifting surface motions as a possible means of load enhancement and control, a dimensionless impulse function that is not dependent on the type of motion is introduced and applied to experimental data. Results suggest that optimum lift performance can be achieved at relatively low pitch rates when the motion is terminated at the rate-determined angle at which the dynamic lift coefficient reaches its maximum value. Author

**A86-11227#**

**THE PITCHING DELTA WING**

M. GAD-EL-HAK and C.-M. HO (Flow Research Co., Kent, WA) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1660-1665. refs
(Contract F49620-80-C-0020)

Delta wings in steady flow can provide high lift at large angles of attack and are therefore used on many high-performance aircrafts. However, the unsteady aerodynamic properties of a delta wing are practically unknown, although vital for operating and designing airplanes for poststall and other maneuvering. In this study, the flowfields around to pitching delta wings with apex angles of 90 and 60 deg were visualized in a towing tank at chord Reynolds numbers up to 350,000. The reduced frequency was varied in the range 0.05-3. The leading-edge separation vortex went through a growth-decay cycle with hysteresis during a pitching period. A distinct change of the separated flow was observed at a reduced frequency around pi. Author

**A86-11230#**

**THREE-DIMENSIONAL CALCULATION OF TRANSONIC VISCOUS FLOWS BY AN IMPLICIT METHOD**

H. HOLLANDERS, A. LERAT, and R. PEYRET (ONERA, Chatillon-sous-Bagneux, France) (Computational Fluid Dynamics Conference, 6th, Danvers, MA, July 13-15, 1983, Collection of Technical Papers, p. 621-629) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1670-1678. Research supported by the Ministere de la Defense. Previously cited in issue 18, p. 2637, Accession no. A83-39412. refs

**A86-11233*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**SECOND-ORDER-ACCURATE SPATIAL DIFFERENCING FOR THE TRANSONIC SMALL-DISTURBANCE EQUATION**

P. M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) and H. D. VAN BUSKIRK AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1693-1699. Previously cited in issue 06, p. 715, Accession no. A84-19230. refs

**A86-11255*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FINITE DIFFERENCE SOLUTIONS OF THE EULER EQUATIONS IN THE VICINITY OF SHARP EDGES**

P.-M. HARTWICH (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1820-1822. refs

Attempts have been made to explain why finite difference solutions of the Euler equations can describe flows with large vortical structures around sharp-edged bodies. The present paper is concerned with the influence of a singular sharp edge on the truncation error for a set of discretized Euler equations. An analysis is conducted of the distribution of the truncation error of one finite difference approximation of the Euler equations near a sharp edge of a thin plate. The analysis leads to a determination of the size of the region of the neighborhood of such a singularity. Attention is given to the consistency of a discretization of the Euler equations, and numerical experiments. G.R.

**A86-11605#**

**A COUPLED INVERSE-INVERSE METHOD FOR OVER-EXPANDED SUPERSONIC NOZZLES**

G. MEAUZE and A. FOURMAUX (ONERA, Chatillon-sous-Bagneux, France) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 45-49. refs
(ONERA, TP NO. 1985-109)

An inverse-inverse coupling method is proposed for taking into account internal flow separations occurring in supersonic nozzles in overexpanded regimes. First, various coupling techniques are briefly reviewed, and a justification is given for the proposed approach. The application to supersonic nozzles is then discussed in more detail, with computations for different overexpanded configurations included. V.L.

**A86-11606#**

**JET PLUME TEMPERATURE EFFECTS ON AFTERBODY PRESSURE DISTRIBUTION AND DRAG**

N. B. MATHUR and K. S. YAJNIK (National Aeronautical Laboratory, Bangalore, India) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 50-55. refs

Experiments have been carried out on an axisymmetric configuration with a circular arc boattailed afterbody to study the jet plume temperature effects on afterbody pressure distribution and drag. It is found that the jet plume temperature systematically affects afterbody pressure distribution and that the afterbody drag decreases with increasing jet plume temperature. At Mach 0.62 and a jet pressure ratio of 2.9, the afterbody pressure drag coefficient at a jet temperature of 945 K is 30-40 percent less than its value at a jet temperature of 307 K (cold jet). V.L.

**A86-11611#**

**THE SHOCK PATTERNS IN THE TWO-DIMENSIONAL INLET WITH A BLEED**

J. B. XING and C. M. CHANG (Beijing Power Plant Research Laboratory, People's Republic of China) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 111-117.

The various shock patterns in the two-dimensional inlet with a bleed slot located in front of a geometric throat were recorded by means of TV tapes. The downstream static pressure was measured to determine the relationship between the total pressure recovery (Po) and the mass flow ratio (Fi). The results indicated that, as the downstream pressure varied, the variations in the terminal shock wave system and of the Po are continuous for this type of inlet. The analysis of the Po and Fi relationship has shown that the relationship is single and continuous. The various patterns of the terminal shock wave system in conditions of different Mach numbers ahead of the geometric throat are discussed. I.S.

**A86-11612#**

**THREE-DIMENSIONAL FLOW EFFECTS IN A TWO-DIMENSIONAL AIR INTAKE WITH MIXED SUPERSONIC COMPRESSION**

S. A. FISHER (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 118-124. refs

The internal flow in a two-dimensional mixed compression intake having focussed internal compression was examined experimentally at its design Mach number of 3.05, using pressure instrumentation and flow visualization. A pair of streamwise vortices was identified, which apparently resulted from interaction of the sidewall boundary layers with the internal shock system and which, depending on detailed geometry, could dominate the flow in the subsonic diffuser. It is argued that similar flows could exist in a variety of intakes designed for supersonic flight, with implications for both turbine and ram compression engine applications. Author

**A86-11615*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NUMERICAL SIMULATION OF SELF-EXCITED OSCILLATIONS IN A RAMJET INLET-DIFFUSER FLOW**

T. HSIEH (U.S. Navy, Naval Surface Weapons Center, Silver Spring, MD) and T. COAKLEY (NASA, Ames Research Center, Moffett Field, CA) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 149-156. Navy-sponsored research. refs

This paper describes numerical simulations of self-excited oscillations in a two-dimensional transonic inlet-diffuser flow by solving the Navier-Stokes equations with a two-equation turbulence model. The calculated amplitudes of oscillations for the terminal shock and the velocity fields compare well with experimental measurements; however, the predicted frequency of oscillations is about 50 percent higher. The formation of a pair of downstream-traveling, counter-rotating vortices at each cycle of velocity fluctuations, as reported experimentally, is vividly revealed by the numerical results. Author

**A86-11616#**

**CALCULATION OF EXTERNAL AND INTERNAL TRANSONIC FLOW FIELD OF A THREE-DIMENSIONAL S-SHAPED INLET**

H. SHEN, L. SHIJUN, M. JI, and Z. XING (Northwestern Polytechnical University, Xian, Peoples Republic of China) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 157-162. refs

A procedure for the numerical solution of the transonic flow about a three-dimensional s-shaped inlet was developed by the hybrid use of two methods: the mixed finite difference method (FDM) and the sweep finite element method (SFEMK). The FDM of the velocity potential equations, applicable to cylindrical ora Cartesian mesh, irrotational schemes and boundary-continuation methods, is used to calculate the external and internal flow fields of a three-dimensional inlet. Then the SFEM is used to improve the accuracy of the computed values of field variables at an embedded domain near the lip of the inlet. The hybrid method was used to combutate the flow about an s-shaped inlet with free stream Mach number 0.8 at different angles of attack. The results were in excellent agreement with the experimental data and with those computed by the perturbation method of Lin (1984). I.S.

**A86-11635#**

**MODERN TECHNOLOGY APPLICATION TO COMPRESSOR AND TURBINE AERODYNAMICS**

J. HOURMOUZIADIS and H.-J. LICHTFUSS (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 307-320. refs

The historical evolution of compressor and turbine design has led to a situation in which the methods used for the analysis of compressor characteristics are different from the approaches employed for turbines. However, as actually the fundamental phenomena involved in both cases are the same, compressor and turbine design systems tend to converge to one single turbomachinery design system. In the near future, transonic and supersonic flow will become dominant in the next generation of turbomachinery for airbreathing engines. Turbomachinery design systems are discussed, taking into account annulus and velocity-triangle design, blade to blade analysis, and three-dimensional analysis and design. It is pointed out that turbomachinery design is becoming an integral part of the engine computer-aided design system. Aspects of experimental research and development are also discussed, giving particular attention to measurement techniques. G.R.

**A86-11636#**

**AN EXPERIMENTAL STUDY OF THE COMPRESSOR ROTOR FLOW FIELD AT OFF-DESIGN CONDITION USING LASER DOPPLER VELOCIMETER**

P. POPOVSKI and B. LAKSHMINARAYANA (Pennsylvania State University, University Park) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 321-330. refs

The measurement of the flow field at the peak pressure rise condition in an axial flow compressor rotor is reported in this paper. The inviscid flow measurement was carried out using a laser Doppler velocimeter and the blade boundary layers were measured using a two sensor hot wire probe. The blade to blade distribution of velocities at several axial and radial locations are plotted, interpreted, and compared with the conditions existing at a lower (design) flow coefficient. The leading edge effects on inviscid flow is found to be appreciable. The flow field is dominated by inviscid flow at most radial locations, and the blade boundary layers thickness is found to be appreciable in the tip region. The flow near the tip is dominated by the leakage flow and its influence is more severe at the peak pressure rise condition. Author

**A86-11639#**

### DEVELOPMENT OF A SHORT RADIAL DIFFUSER IN THE HIGH SUBSONIC AND SUPERSONIC RANGE WITH SPECIAL APPLICATION TO AIR BREATHING ENGINES

W. WAWSZCZAK (Calgary, University, Canada) and J. DE KRASINSKI IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 344-350. NSERC-sponsored research. refs

This paper describes the experimental research done on a very short, axially symmetrical diffuser. This diffuser, developed originally for low speed, has been redesigned for high subsonic and supersonic ranges with the objective of meeting high efficiency and low aerodynamic noise criteria. Besides the classical boundary layer concepts required to avoid separation, general trends following from Lighthill's concepts of aerodynamically generated sound were also adopted. The results are more than encouraging. Shortness, high efficiency and almost complete noise abatement have been achieved. Author

**A86-11675#**

### TURBULENT BOUNDARY LAYER SEPARATION ON ENGINE COMPONENTS

W. H. SCHOFIELD (Aeronautical Research Laboratories, Melbourne, Australia) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 631-639. refs

A unified description of the entire separating turbulent flow field is presented by coupling a proposed description for the mean velocity profile of turbulent boundary layers (b.l.s.), in flow approaching separation, during separation, and downstream after separation, and an empirical formulation for the mean reversed flow profile. It was found that the velocity profiles in adverse pressure gradient b.l.s. defined by Schofield and Perry (1972, 1973) can be extended to separating and separated layers, provided that the effective origin of the layer is relocated. It is proposed that turbulent b.l.s. separate with a universal mean velocity profile, which can be defined by a standard shape factor (displacement to momentum thickness ratio) of 3.3. The application of this theory to practical b.l.s. with three-dimensional components is discussed. I.S.

**A86-11692#**

### RECENT PROGRESS ON COMPRESSOR STABILITY IN FRANCE

J. CHAUVIN (Marseille II, Universite, France) and PH. RAMETTE (DRET, Paris, France) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 758-764. refs

A discussion of numerical models for predicting the stability limits of an aircraft's axial and centrifugal compression systems in terms of rotating stall, surge and flutter is presented, including modeling of the response of an axial compressor to a distorted inlet flow. Calculated values on surge line are compared with the experimental data. I.S.

**A86-11912#**

### THE GOVERNING INFLUENCE OF THE NOSE RADIUS ON THE UNSTEADY EFFECTS OF LARGE SCALE FLOW STRUCTURE IN THE TURBULENT WING AND PLATE JUNCTION FLOW

E. P. ROOD (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Forum on unsteady flow; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 7-9.

Experimental results are reported from trials to quantify the effects of two values of the ratio of the nose radius to the boundary layer thickness (RTBL). The studies were conducted with a wing section attached to a rigid plate, with data taken one chord length downstream from the wing, which was at a 5.0 deg angle of attack. The flow velocity was 30 m/sec. Values of the RTBL of 0.12 and 0.71 were examined. The wing nose radius had a significant effect on the across-stream unsteady flow spatial pattern produced by convective structures at the downstream interaction between the boundary layer and wake. The nose radius also influences the location and skew of the surface dividing unsteady flows from the two sides of the wing. M.S.K.

**A86-12020#**

### CRITICAL EXAMINATION OF TURBULENCE MODELS FOR A SEPARATED THREE DIMENSIONAL TURBULENT BOUNDARY LAYER

R. SCHMITT (ONERA, Chatillon-sous-Bagneux, France) and R. ABID La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1984, p. 1-17. refs

Four turbulence models are evaluated in comparisons with experimental data on the evolution of a three-dimensional boundary layer to separation. Attention is given to an algebraic mixing length theory, a kinetic energy-dissipation rate (k-e) model, an algebraic stress model (ASM), and a model comprising four transport equations. Solutions are obtained by a finite difference technique in an inverse mode. The mixing length model consistently overestimates the growth of shear stresses once destabilization is initiated. The ASM is the only model which correctly portrays the changes in shear stresses observed, and also the associated lag phenomena and velocity profiles. Further work is still necessary to model the wall flow. M.S.K.

**A86-12021#**

### A VORTEX POINT METHOD FOR CALCULATING INVISCID INCOMPRESSIBLE FLOWS AROUND ROTARY WINGS

B. CANTALOUBE (ONERA, Chatillon-sous-Bagneux, France) and S. HUBERSON (CNRS, Paris, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1984, p. 19-31. refs

An integral method is presented for calculating incompressible inviscid unsteady flow around thin bodies in arbitrary motion, i.e., rotor blades in motion with respect to one another. Because an integral method is used, discretization is limited to the solid boundaries and the vortices. Boundary conditions are treated in terms of equation for the slipstream on the walls, the vorticity vector, a volume integral for the vorticity and a first-order Fredholm integral. The Helmholtz equation governs the evolution of vorticity, which forms a sheet of doublets. The pressure jumps on the blades are covered by the unsteady Bernoulli equation. Applications of the method to helicopter rotors, medium- and high-aspect ratio propellers and low-aspect ratio nautical propellers are demonstrated. M.S.K.

**A86-12022#**

### EFFECT OF THE REYNOLDS NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF AN OGIVE-CYLINDER AT HIGH ANGLE OF ATTACK

P. CHAMPIGNY (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1984, p. 33-41. refs

Low-speed wind tunnel data for an ogive model at high angles of attack (AOA) are analyzed in terms of the flow separation regimes. The flows covered the Re range of 280,000-2 million, AOAs up to 80 deg and a Mach 0.35 flow velocity. The sting-mounted model was instrumented with 354 pressure taps. The data were used to calculate the normal and side forces. The drag coefficient was found to be dependent on the Re and the AOA. Both laminar and turbulent flows produced large side forces, which had cyclic distributions. Finally, the separations that occurred produced four types of flows for separate Re regimes. M.S.K.

**A86-12024#**

### DYNAMIC STALL MODELING OF THE NACA 0012 PROFILE

D. PETOT (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1984, p. 55-58. refs

Correlations obtained by ONERA researchers in studies of large amplitude oscillations in airfoils are discussed. The correlation

values were generated with a dynamic model for helicopter rotor blades experiencing nonlinear oscillations in the lift/angle of attack or moment/angle of attack hysteresis loops. Comparisons were made between the model predictions and data from NASA experiments with NACA 0012 airfoils at varying angles of attack, amplitudes and frequencies. The model proved adequate for predicting the hysteresis loops and in identifying stall behavior.
M.S.K.

**A86-12062**
**THREE-DIMENSIONAL SOLUTIONS TO THE EULER EQUATIONS WITH ONE MILLION GRID POINTS**
A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 1, Sept. 1985, p. 193-198. Research supported by the Control Data Corp. refs

Three dense-mesh solutions are presented. The first solution, for the M6 wing (Mach 0.84, alpha 3.06 deg), shows only slight improvements in accuracy in comparison with earlier standard-mesh solutions. The other two solutions, for subsonic and supersonic flow around the 70-deg swept Dillner wing, reveal flow fields of much more complex expansion and compression phenomena than do the standard-mesh solutions. In both cases, weak and local shock waves interact with the vortex over the wing. The sequence of lift and drag coefficients is presented for three levels of grid density, 33 x 11 x 15 (coarse), 65 x 21 x 29 (standard), and 193 x 57 x 97 (dense).
V.L.

**A86-12263#**
**UNSTEADY AERODYNAMIC CHARACTERISTICS OF A BLADE IN PITCHING OSCILLATIONS WITH FLOW SEPARATION. I - THE CASE WITH LAMINAR SEPARATION BUBBLE. II - THE CASE WITH LEADING EDGE STALL. III - THE CASE NEAR THE STALLING ANGLE OF ATTACK**
I. FUJIMOTO, K. YAMAGUCHI (Tokyo, University, Japan), H. TANAKA (Tokai University, Hiratsuka, Japan), and S. ISHII (Nihon University, Chiba, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1610-1633. refs

**A86-12265#**
**STRUCTURE AND DECAY OF SECONDARY FLOW IN THE DOWNSTREAM OF A CASCADE**
T. KAWAI, T. ADACHI (Tsukuba, University, Sakura, Japan), and K. AKASHITA (Nissan Motor Co., Ltd., Yokosuka, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1642-1650. refs

An experimental investigation has been done on trailing and passage vortices downstream of a decelerating cascade. Hot wire traverses gave distributions of secondary flow velocities and streamwise vorticities at four axial locations. A spanwise distribution of passage circulations per unit span agrees well with a prediction by an inviscid classical secondary flow theory. The trailing vortex is well approximated by a vortex sheet immediately downstream of the blade, beginning to roll up at the position of maximum circulation per unit span. It develops into an almost axisymmetric vortex two chord lengths downstream. The trailing vortex decays faster in the vicinity of the blade trailing edge but more slowly far downstream, than the passage vortex does. The experimental trailing vortex is generated very far away from an endwall as compared with a theoretical position, exerting significant influences on the maximum underturning and the pitch-averaged streamwise vorticity in the main flow region.
Author

**A86-12266#**
**A STUDY OF AERODYNAMIC PERFORMANCE OF DIFFUSERS FOR CENTRIFUGAL COMPRESSORS**
Y. YOSHINAGA, H. KOBAYASHI (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Tsuchiura, Japan), and T. KANEKI (Hitachi, Ltd., Tsuchiura, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1651-1658. refs

The performance of vaneless diffusers and the flow distribution discharged from the impellers of various specific speed centrifugal compressors were studied. The experimental results of 18 different stages showed that the impeller exit flow distortion in the axial direction increased with an increase in specific speed, and the pressure recovery of vaneless diffusers for high specific speed compressors was extremely low compared with the value expected by an ideal two-dimensional analysis. New type diffusers with half guide vanes on the shroud sidewall are proposed to improve the pressure recovery of the diffuser under the distorted inlet flow condition. The results show that the pressure recovery of the diffuser under distorted inlet flow is considerably improved by half guide vanes, and the best height of the guide vanes is a little less than half the diffuser width.
Author

**A86-12267#**
**THE PERFORMANCE CHARACTERISTIC OF AN AIR-SEPARATOR OF AN AXIAL FLOW FAN**
Y. MIYAKE (Osaka University, Suita, Japan), I. NOJI (Nissan Motor Co., Ltd., Atsugi, Japan), Y. NISHIKAWA (Toshiba Co., Ltd., Yokohama, Japan), and S. MURATA (Toyoda Technical Institute, Nagoya, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1659-1666. refs

An air-separator as a new means for stabilizing the characteristics in the low flow rate region of an axial flow fan has been studied experimentally. The influence on the performance of this equipment of such parameters as the structure of the flow passage and the dimensions has been examined, as well as the influence of the hub-tip ratio of the rotor and the aspect ratio of the rotor blades. It is found that the equipment is useful even in conditions where blade separators are useless.
Author

**A86-12271#**
**CHARACTERISTICS OF THE FLOW AROUND RECTANGULAR CYLINDERS - THE CASE OF THE ANGLE OF ATTACK 0 DEG**
T. IGARASHI (Defense Academy, Yokosuka, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1690-1696. refs

Experimental investigations on the characteristics of the flow around rectangular cylinders were carried out in the range of subcritical Reynolds numbers. The width-to-height ratio (C/d) of the sections was varied from 0.1 to 4.0. The fluctuating pressure coefficient has a maximum in the same tendency as that of the drag coefficient when C/d = 0.67. The differences in flow patterns between two critical values of the ratios C/d = 0.67 and 2.8 become clear. The flow around the cylinder with arc-like leading-edge corners has been found to agree closely with that around the cylinder with a larger value of the ratio of C/d.
Author

**A86-12283#**
**EXPERIMENTAL STUDY OF VORTEX BREAKDOWN ON A DELTA WING IN INCOMPRESSIBLE FLOW [ETUDE EXPERIMENTALE DE L'ECLATEMENT DU TOURBILLON D'UNE AILE DELTA EN ECOULEMENT INCOMPRESSIBLE]**
D. PAGAN (ONERA, Chatillon-sous-Bagneux, France) (Congres Francais de Mecanique, 7th, Bordeaux, France, Sept. 2-6, 1985) ONERA, TP, no. 1985-107, 1985, 5 p. In French.
(ONERA, TP NO. 1985-107)

The average and fluctuation characteristics of a vortex-breakdown field on a delta wing were obtained in a laser-velocimeter study at an angle of attack of 19.3 deg and a flow velocity of 14.5 m/s. Results are presented concerning the meridional and tangential components of the velocity field, and the spatial distribution of fluctuation terms. A histogram of the instantaneous velocity components u and v is also presented.
B.J.

**A86-12551**
**REPRESENTATION OF A TURBINE PROFILE IN THE FORM OF A BEZIER CURVE [PREDSTAVLENIE TURBINNOGO PROFILIA V FORME KRIVOI BEZ'E]**
B. KH. PERELSHTEIN and S. S. SOLOVEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 91-94. In Russian. refs

A method for representing plane turbine profiles by a Bezier curve has been developed as part of an effort to create graphics software support for a computer-aided design system. The shape of the curve is determined by the position of the vertices of the corresponding polyhedron. A change in the coordinates of the vertices leads to a gradual change in the shape of the curve, which makes it possible to optimize the profile and eventually the blading surfaces of turbomachines when using three-dimensional gasdynamic models. The representation of an aerodynamic curve in the form of a Bezier curve provides a good intuitive relation between the curve and the reference points, which is important when changes are made directly in the graphic image in an interactive manner. V.L.

**N86-10002#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SECOND ORDER APPROXIMATION METHOD FOR TRANSONIC FLOWS OVER SWEPT WINGS**

S. KEYANG (Shanghai Aviation Industry Corp.) *In its* Acta Aeron. and Astronautica Sinica (FTD-ID(RS)T-1120-84) p 1-17 4 Oct. 1984 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 4, 1983 p 1-10
Avail: NTIS HC A04/MF A01 CSCL 01A

The TSDH equation is used to calculate the transonic flows over three dimensional swept wings. It considers the leading edge boundary conditions and leading edge velocity potential equation suitable for the blunt leading edge of wings. The expanded form of the Jameson scheme is used in the unequal step length grid for the discretization of the TSDH equation into a set of finite difference equations. A rarefied grid was arranged in the calculation space, then a dense grid was arranged near the wing and alternate iteration of the rarefied and dense meshes was carried out so as to accelerate convergence and raise calculation precision. Calculations of the supercritical without shock wave and with shock wave conditions of the ONERA M6 wing show that there is good agreement between the TSDH solution and the FVP solution and wind tunnel tests. Author

**N86-10003#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**A NUMERICAL SOLUTION OF THE SHOCK-TURBULENT INTERACTION OVER A COMPRESSION CORNER FOR SUPERSONIC FLOW**

C. QIPENG (Nanjing Aeronautical Inst.) *In its* Acta Aeron. et Astronautica Sinica (FTD-ID(RS)T-1120-84) p 18-33 4 Oct. 1985 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 4, 1983 p 11-19
Avail: NTIS HC A04/MF A01 CSCL 01A

The shock turbulent boundary layer interaction over a compression corner for supersonic flow is calculated. The calculations use the Cebeci-Kellet box method; the turbulence model uses the algebraic eddy viscosity model; the pressure strength distribution uses the unified hypersonic and supersonic formulas of flowing over a wedge. Iteration correction is carried out of the shock turbulent boundary layer disturbance. The calculations predict the wall pressure distribution as well as the initial rise point location of the pressure. Author

**N86-10008#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**NUMERICAL SOLUTION OF HYPERSONIC FLOW NEAR LEADING EDGE OF A FLAT PLATE**

D. FU *In its* Three Articles on New Calculation Methods in Aeron. (Selected Articles) (FTD-ID(RS)T-0910-84) p 1-14 17 Aug. 1984 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 3, Sep. 1983 p 1-8 Original language document announced in IAA as A84-23903
Avail: NTIS HC A04/MF A01 CSCL 01B

A one-step difference scheme for solving two-dimensional steady state Navier-Stokes equations is proposed to handle supersonic and hypersonic viscous interaction problems near the leading edge of a flat plate. The scheme is considered and analyzed with a model equation. It has second-order accuracy in space for steady state problems and its stability condition is improved. The scheme is much simpler, compared to the commonly used two-step predictor-corrector difference scheme for N-S equations and also is convenient for programming. Two viscous interaction problems are solved with the proposed scheme; the solutions are valid throughout the boundary layer, shock-wave structure, and inviscid core. The results show good agreement with experimental data. The numerical solutions show that the nonslip conditions can be used for weak viscous interaction. C.D. (IAA)

**N86-10009#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**A NEW METHOD FOR CALCULATING UNSTEADY SUPERSONIC AERODYNAMIC FORCES AND ITS APPLICATION**

X. WANG *In its* Three Articles on New Calculation Methods in Aeron. (Selected Articles) (FTD-ID(RS)T-0910-84) p 15-31 17 Aug. 1984 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 3, Sep. 1983 p 9-18
Avail: NTIS HC A04/MF A01 CSCL 01B

This paper proposes a new method for calculating supersonic unsteady aerodynamic forces. It combines the piston theory for unsteady supersonic flow with the conical flow theory for steady flow so that the interaction between points on a wing neglected in the piston theory is approximated by the conical flow theory. This method was used in this paper for flutter calculations of 29 cases for wings with 10 different types of plane forms. The results were compared with flutter test results obtained in wind tunnels and they were in satisfactory agreement. It was especially the case that the accuracy of flutter analysis improved by this method was noticeably higher than that obtained by the piston theory. This shows that this method is reliable and feasible for supersonic flutter analysis. It possesses the advantages of being a more succinct method and having higher calculation accuracy, less computing time and easier programming. Author

**N86-10010#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**EFFECT OF A SHEAR LAYER ON THE STABILITY OF AN AXISYMMETRICAL EXTERNAL COMPRESSION AIR INTAKE**

K. ZHANG, S. YU, and C. PENG *In its* Three Articles on New Calculation Methods in Aeron. (Selected Articles) (FTD-ID(RS)T-0910-84) p 32-42 17 Aug. 1984 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 3, Sep. 1983 p 56-62
Avail: NTIS HC A04/MF A01 CSCL 01B

The influence of shear layers of various strengths on the stability of an axisymmetric compression supersonic air intake is studied. Strength is defined as the ratio of total pressure difference between the two sides of a shear layer to the total pressure of the incoming flow. Six central bodies with different cone angles were used to produce shear layers with strengths ranging from 5 to 11 percent of the total pressure of upstream flow inside a free stream wind tunnel with a fixed Mach number of 1.72. Shear layers with less than 10 percent strength were strong enough to cause separation of the boundary layer from the inside surface of the cowl. Shear layers of strength less than 11 percent failed to induce buzz in the axisymmetric intake. The influence of a shear layer depended on its distance from the lip of the cowl, and was most noticeable at a distance of 10 to 18 percent of the cowl radius. C.D. (IAA)

**N86-10011#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**COMMENT ON DETERMINATION OF AERODYNAMIC COEFFICIENTS FOR A REENTRY BODY BY MEANS OF THE KALMAN FILTER METHOD**

J. CAI *In its* Three Articles on New Calculation Methods in Aeron. (Selected Articles) (FTD-ID(RS)T-0910-84) p 43-46 17 Aug. 1984 Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 3, Sep. 1983 p 102-104
Avail: NTIS HC A04/MF A01 CSCL 01B

Research emphatically indicates that a mathematical model for aerodynamic parameter identification of a reentry body bases only on the data of angular rates and accelerations onboard but not on trajectory observation data. It can only determine the ratio between aerodynamic coefficients of the reentry body but can't determine the aerodynamic coefficients directly. B.W.

**N86-10012** Georgia Inst. of Tech., Atlanta.

**A STUDY OF THE AERODYNAMIC PERFORMANCE OF WEIS-FOGH WINGS Ph.D. Thesis**

H. H. CHEN 1985 145 p

Avail: Univ. Microfilms Order No. DA8510956

A general theory of aerodynamics developed on the basis of viscous flow equations, is utilized in an investigation of the Weis-Fogh problem. The general theory is ideally suited for nonlinear unsteady aerodynamic problems. It is also shown that the general theory permits the important flow elements dominating the aerodynamics of nonlinear unsteady flows to be identified and their contributions evaluated individually. The Weis-Fogh problem is a well known biofluiddynamics problem involving articulate lifting bodies. The present study has yielded useful results for the lift and drag acting on a wing undergoing the fling and the clap phases of the Weis-Fogh motion. Closed form expressions have been obtained for the unsteady aerodynamic forces and the power expenditure of the Weis-Fogh wing. These results have led to the identification of major contributions to aerodynamic performance of the Weis-Fogh wings and to an assessment of the relative importance of these contributions. Dissert. Abstr.

**N86-10013** Princeton Univ., N. J.

**ON THE DESIGN OF AIRFOILS IN TRANSONIC FLOW USING THE EULER EQUATIONS Ph.D. Thesis**

J. F. FAY 1985 83 p

Avail: Univ. Microfilms Order No. DA8509636

This work falls naturally into two parts. One part describes a computer program that designs airfoils using the Lighthill method of conformal mappings. This program involves the use of the Euler equations to solve for the flow past a given initial shape, and also around intermediate shapes. The other part is a derivation of an extension of the Lighthill method to compressible flows with the assumptions of potential flow and small disturbances of the free stream. The description of the program speaks to its various aspects, namely the Euler solution formulation and the actual process of design. Several other topics are also mentioned; these include several factors affecting the rate of convergence of the design process, the importance of equaling the lift coefficients of the initial and final shapes; and the effect of using the same design velocity distribution at different freestream Mach numbers. There is a short appendix giving a plausible argument indicating that the interaction for small disturbance and arbitrary subsonic Mach number will converge to a desired shape. Dissert. Abstr.

**N86-10014*#** Vanderbilt Univ., Nashville, Tenn. Dept. of Mechanical and Materials Engineering.

**THE ROLE OF FREESTREAM TURBULENCE SCALE IN SUBSONIC FLOW SEPARATION Interim Progress Report, 1 Jan. - 30 Jun. 1985**

J. L. POTTER, W. R. SEEBAUGH, C. E. FISHER, R. J. BARNETT, and R. B. GOKHALE 30 Jun. 1985 56 p

(Contract NAG1-483)

(NASA-CR-176237; NAS 1.26:176237; IPR-2) Avail: NTIS HC A04/MF A01 CSCL 01A

The clarification of the role of freestream turbulence scale in determining the location of boundary layer separation is discussed. Modifications to the test facility were completed. Wind tunnel flow characteristics, including turbulence parameters, were determined with two turbulence generating grids, as well as no grid. These results are summarized. Initial results on the role of scale on turbulent boundary layer separation on the upper surface of an airfoil model are also discussed. Author

**N86-10015*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EVALUATION OF AN AERODYNAMIC-LOAD PREDICTION METHOD ON A STOL FIGHTER CONFIGURATION**

J. KATZ Aug. 1985 33 p refs Previously announced as N85-33121

(NASA-TM-86782; REPT-85358; NAS 1.15:86782) Avail: NTIS HC A03/MF A01 CSCL 01A

A three-dimensional panel method was used to compute the aerodynamic loads on a large-scale, powered wind tunnel model. The size of the computation grid was selected such that turnaround times, on present computers remained satisfactory. With this constraint, the STOL aircraft configuration was modeled and the capabilities and limitations of the prediction method were investigated. After this study, a similar numerical model was established for a forward-swept-wing aircraft configuration which is planned for large-scale, low-speed testing. The resulting aerodynamic-load predictions are discussed and will be utilized, together with the future experimental results, to obtain a broader validation of this method as well as to reduce the necessary size of the matrix of the test parameters. Author

**N86-10016*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**OPERATING CHARACTERISTICS OF THE MULTIPLE CRITICAL VENTURI SYSTEM AND SECONDARY CALIBRATION NOZZLES USED FOR WEIGHT-FLOW MEASUREMENTS IN THE LANGLEY 16-FOOT TRANSONIC TUNNEL**

B. L. BERRIER, L. D. LEAVITT, and L. S. BANGERT Sep. 1985 74 p refs

(NASA-TM-86405; L-15960; NAS 1.15:86405) Avail: NTIS HC A04/MF A01 CSCL 01A

An investigation has been conducted in the Langley 16 Foot Transonic Tunnel to determine the weight flow measurement characteristics of a multiple critical Venturi system and the nozzle discharge coefficient characteristics of a series of convergent calibration nozzles. The effects on model discharge coefficient of nozzle throat area, model choke plate open area, nozzle pressure ratio, jet total temperature, and number and combination of operating Venturis were investigated. Tests were conducted at static conditions (tunnel wind off) at nozzle pressure ratios from 1.3 to 7.0. Author

**N86-10017*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**THREE-DIMENSIONAL INVISCID ANALYSIS OF RADIAL TURBINE FLOW AND A LIMITED COMPARISON WITH EXPERIMENTAL DATA**

Y. K. CHOO and K. C. CIVINSKAS (Army Aviation Research and Technology Activity) 1985 28 p refs To be presented at the ASME Winter Ann. Meeting, 3-Dimensional Flow Phenomena in Fluid Machinery Symp., Miami, Fla., 17-22 Nov. 1985

(NASA-TM-87091; E-2679; NAS 1.15:87091; USAAVSCOM-TR-85-C-12) Avail: NTIS HC A03/MF A01 CSCL 01A

The three-dimensional inviscid DENTON code is used to analyze flow through a radial-inflow turbine rotor. Experimental data from the rotor are compared with analytical results obtained by using the code. The experimental data available for comparison are the radial distributions of circumferentially averaged values of absolute flow angle and total pressure downstream of the rotor exit. The computed rotor-exit flow angles are generally underturned relative to the experimental values, which reflect the boundary-layer separation at the trailing edge and the development of wakes downstream of the rotor. The experimental rotor is designed for a higher-than-optimum work factor of 1.126 resulting in a nonoptimum positive incidence and causing a region of rapid flow adjustment and large velocity gradients. For this experimental rotor, the computed radial distribution of rotor-exit to turbine-inlet total pressure ratios are underpredicted due to the errors in the finite-difference approximations in the regions of rapid flow adjustment, and due to using the relatively coarser grids in the middle of the blade region where the flow passage is highly

three-dimensional. Additional results obtained from the three-dimensional inviscid computation are also presented, but without comparison due to the lack of experimental data. These include quasi-secondary velocity vectors on cross-channel surfaces, velocity components on the meridional and blade-to-blade surfaces, and blade surface loading diagrams. Computed results show the evolution of a passage vortex and large streamline deviations from the computational streamwise grid lines. Experience gained from applying the code to a radial turbine geometry is also discussed.
Author

**N86-10018*#** National Aeronautics and Space Administration. Johnson (Lyndon B.) Space Center,
**NUMERICAL PROCEDURE FOR THREE-DIMENSIONAL HYPERSONIC VISCOUS FLOW OVER AEROBRAKE CONFIGURATION**
C. P. LI Aug. 1985 17 p refs
(NASA-TM-58269; S-549; NAS 1.15:58269) Avail: NTIS HC A02/MF A01 CSCL 01A

A numerical method, which is simpler and more efficient than others currently in use, is proposed for the computation of the full viscous flow over an aerobrake body in hypersonic stream at high altitude. It treats the shock layer surrounding the blunt forebody and the near wake behind the base simultaneously by formulating the Navier-Stokes equations in conformal and azimuthal-angle coordinates. The computational domain is confined by the body wall, outflow surface and the shock, which is adjusted along the coordinate normal to the wall in the course of iterations. Because of the optimal grid and a well developed alternating direction implicit factorization technique for the governing equations, reasonably accurate results can be obtained with a 28 x 36 x 7 grid and 400 time-marching iterations. Excellent agreement of shock location is found between the present result and the schlieren photograph. Details of the base flow and shear layer impingement on the cylindrical aft body are presented for an adiabatic wall case.
Author

**N86-10019*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**FORCED RESPONSE ANALYSIS OF AN AERODYNAMICALLY DETUNED SUPERSONIC TURBOMACHINE ROTOR**
D. HOYNIAK and S. FLEETER (Purdue Univ., West Lafayette, Ind.) 1985 24 p refs Presented at 10th Bien. Design Eng. Div. Conf. and Exhibit on Mech. Vibration and Noise, Cincinnati, 10-13 Sep. 1985; sponsored by ASME
(NASA-TM-87093; E-2685; NAS 1.15:87093) Avail: NTIS HC A02/MF A01 CSCL 01A

High performance aircraft-engine fan and compressor blades are vulnerable to aerodynamically forced vibrations generated by inlet flow distortions due to wakes from upstream blade and vane rows, atmospheric gusts, and maldistributions in inlet ducts. In this report, an analysis is developed to predict the flow-induced forced response of an aerodynamically detuned rotor operating in a supersonic flow with a subsonic axial component. The aerodynamic detuning is achieved by alternating the circumferential spacing of adjacent rotor blades. The total unsteady aerodynamic loading acting on the blading, as a result of the convection of the transverse gust past the airfoil cascade and the resulting motion of the cascade, is developed in terms of influence coefficients. This analysis is used to investigate the effect of aerodynamic detuning on the forced response of a 12-blade rotor, with Verdon's Cascade B flow geometry as a uniformly spaced baseline configuration. The results of this study indicate that, for forward traveling wave gust excitations, aerodynamic detuning is very beneficial, resulting in significantly decreased maximum-amplitude blade responses for many interblade phase angles. Author

**N86-10020#** Department of the Air Force, Washington, D.C.
**SUBMERGED RAM AIR INLETS FOR ECM (ELECTRONIC COUNTERMEASURES) PODS Patent Application**
FOXWELL, inventor (to Air Force) 27 Jun. 1985 15 p
(AD-D011801; US-PATENT-APPL-SN-749333) Avail: NTIS HC A02/MF A01 CSCL 21E

The present invention utilizes a substantially pear-shaped submerged air inlet duct in the surface of an electronic countermeasures (ECM) pod to provide cooling air for heat exchanger units which are utilized to cool electronic components in a ECM pod. The smaller opening is in the forward most position. GRA

**N86-10021#** Sandia National Labs., Albuquerque, N. Mex.
**INVISCID FLOW FIELD ANALYSIS OF MANEUVERING HYPERSONIC VEHICLES USING THE SCM FORMULATION AND PARABOLIC GRID GENERATION**
R. W. NOACK 1985 13 p Presented at the 18th Fluid Dyn., Plasma Dyn. and Lasers, Cincinnati, 16 Jul. 1985
(Contract DE-AC04-76DP-00789)
(DE85-013950; SAND-84-2670C; CONF-850717-1) Avail: NTIS HC A02/MF A01

The split-coefficient matrix (SCM) form of the Euler equations for a cylindrical base coordinate system is extended to allow the use of a generalized three-dimensional grid generation scheme. A grid generation scheme based on a parabolic partial differential equation is developed. Grids are obtained without iteration by marching from the body to the shock with body and shock points specified. The SCM type body boundary condition has been found to underpredict surface pressure for geometries with small radii of curvature. An improved method of characteristic (MOC) type body boundary condition has been developed which uses SMC type differencing in the crossflow direction. The improved MOC boundary condition has been found to have the robustness of the SCM type scheme while having superior accuracy. Solutions using the SCM form of the Euler equations with the parabolic grid generator and the improved MOC body boundary condition have been obtained for a hypersonic six fin missile. Generally good agreement is found in comparisons of the inviscid predictions with experimental data. DOE

**N86-10022#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.
**THEORETICAL STUDY OF THE UNSTEADY LINEAR PROBLEM FOR A RECTANGULAR WING WITH A PITCHING MOVEMENT Final Report [ETUDE THEORIQUE DU PROBLEME INSTATIONNAIRE LINEAIRE POUR UNE AILE RECTANGULAIRE ANIMEE D'UN MOUVEMENT DE TANGAGE]**
C. CONEIM Jun. 1984 35 p refs In FRENCH
(Contract DRET-83-34-135)
(ONERA-RT-17/1841-RY-010-R) Avail: NTIS HC A03/MF A01

The pressure distribution on a helicopter rectangular wing with a positive angle of attack and a harmonic pitching movement is computed. The flow separation is not taken in account as the incidence is assumed to be low. The treatment of the singularity is detailed. Results for relatively high frequencies and three profiles are presented. The three dimensional effects of the wing tip are shown. Author (ESA)

**N86-10023#** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
**AERODYNAMICS OF HYPERLIFT SYSTEMS [AERODYNAMIQUE DES SYSTEMES HYPERSUSTENTATEURS]**
P. CAPBERN, J. JAVELLE, N. LARGER, A. J. PAUT, and C. BONNET 23 Jan. 1985 97 p refs In FRENCH
(Contract DRET-83-34-051-00-470-75-01)
(SNIAS-443.501/85) Avail: NTIS HC A05/MF A01

A method to compute two dimensional noncompressible viscous flow on multiprofile configurations is described. The potential flow and the viscous layers are solved interactively. The potential flow is obtained by a singularities method. The boundary layers are

treated by integral equations. Evaluation using the ATR 42 configuration (narrow slots, separated flow) shows the robustness of the method when treating difficult problems and a good prediction of separation and pressure distribution. The computer program is adapted to industrial utilization on CRAY 1 computer.
Author (ESA)

**N86-10024#** Societe Nationale Industrielle Aerospatiale, Toulouse (France).
**ANALYSIS OF HYPERLIFT SYSTEMS. STUDY OF A SINGULARITIES METHOD [ANALYSE DES SYSTEMES HYPERSUSTENATATEURS. ETUDE D'UNE METHODE DE SINGULARITES]**
N. LARGER 10 Sep. 1984 42 p In FRENCH
(SNIAS-443.529/84; SNIAS-443.501/85) Avail: NTIS HC A03/MF A01

Singularity models are tested to solve problems imposed by narrow airfoil profiles commonly found in industrial configurations. Solutions including computation phases, skeleton and thick profile, and the adoption of vortices for either the skeleton or the full profile are described. The results obtained are better than those from classic methods.
Author (ESA)

**N86-10025#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abt. Hochgeschwindigkettsstroemungen.
**INVESTIGATIONS ON A SUPERCRITICAL AIRFOIL WITH BOUNDARY LAYER SUCTION THROUGH A PERFORATED STRIP IN THE SHOCK REGION**
P. KROGMANN Nov. 1984 56 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-940)
(DFVLR-FB-85-15; ISSN-0171-1342) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 16.50

The effect of local boundary layer suction through a perforated strip on the flow development and aerodynamic characteristics of a transonic airfoil is investigated in a 1 m X 1 m transonic wind tunnel. In comparison with reference measurements on the same model with a solid surface, the results show that, aside from the improvements due to suction, the flow development in the non-suction case is most favorably affected by the arrangement of the perforated strip with a cavity underneath. Due to a secondary flow through the perforation and cavity, caused by the strong adverse pressure gradients occurring at higher angles of attack, the shock location as well as the flow field downstream of the shock are affected. Thus, considerable gain in maximum lift and drag reductions can be achieved.
Author (ESA)

**N86-10026#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Forschungsbereich Stroemungsmechanik.
**EXPERIMENTAL AND THEORETICAL INVESTIGATIONS OF THE FLOW AROUND AIRFOIL SYSTEMS WITH GROUND EFFECT**
D. STEINBACH Sep. 1984 63 p refs
(DFVLR-FB-85-17; ISSN-0171-1342) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 21.50

For two rectangular wings with flaps (Q/R4 and NACA 4415) pressure distribution for plane flow and low flow velocities is measured. For ground simulation fixed ground boards adjustable in height are used. Reynolds and Mach numbers are 1.6 million and 0.15. For the NACA 4415 wing flow field measurements are carried out also. The surface singularity method with separation model used for the calculations is outlined. Agreement between experiment and theory is good to satisfactory, especially if flow separation is not too large. But even for large separated flow regions the separation model improves results. The presence of ground gives enlarged flow separation, higher pressure and base pressure values, and lower suction peaks. High-lift systems with positive camber line show considerable losses of lift near ground. A static instability of lift with respect to ground distance occurs. This effect becomes stronger as the angle of attack is increased.
Author (ESA)

**N86-11183** Kansas Univ., Lawrence.
**INLET FLOW DYNAMIC DISTORTION PREDICTION WITHOUT RMS MEASUREMENTS Ph.D. Thesis**
Y. S. CHEN 1984 118 p
Avail: Univ. Microfilms Order No. DA8513816

A two-equation turbulence model, k-epsilon model, is used in the prediction of inlet flow dynamic distortion of jet aircraft based on steady state total pressure measurements only. This Turbulence model is solved at the compressor face station by using a finite difference scheme. Total pressure rms level of the inlet flow is predicted by the turbulence model. The Melick statistical method is then employed to estimate the peak dynamic distortion based on the analytically predicted total pressure rms level. A statistical method is developed for the estimation of boundary conditions for the turbulent equations. In order to solve the set of nonlinear, coupled turbulent equations, an implicit formulation is utilized such that a set of discretized finite difference equations can be arranged into tridiagonal matrix equations for efficient numerical iterations. Results of the prediction compare well with experimental measurements of subsonic, transonic and supersonic inlets under various flight conditions. The present method can be used in the preliminary inlet design phases to reduce the design costs.
Dissert. Abstr.

**N86-11186*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**EFFECT OF AILERON DEFLECTIONS ON THE AERODYNAMIC CHARACTERISTICS OF A SEMISPAN MODEL OF A SUBSONIC ENERGY-EFFICIENT TRANSPORT**
P. F. JACOBS Oct. 1985 344 p refs
(NASA-TP-2478; L-15934; NAS 1.60:2478) Avail: NTIS HC A15/MF A01 CSCL 01A

An investigation was conducted in the Langley 8 Foot Transonic Pressure Tunnel to determine the effect of aileron deflections on the aerodynamic characteristics of a subsonic energy efficient transport (EET) model. The semispan model had an aspect ratio 10 supercritical wing and was configured with a conventionally located set of ailerons (i.e., a high speed aileron located inboard and a low speed aileron located outboard). Data for the model were taken over a Mach number range from 0.30 to 0.90 and an angle of attack range from approximately -2 deg to 10 deg. The Reynolds number was 2.5 million per foot for Mach number = 0.30 and 4 million per foot for the other Mach numbers. Model force and moment data, aileron effectiveness parameters, aileron hinge moment data, otherwise pressure distributions, and spanwise load data are presented.
Author

**N86-11187#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
**GROUND EFFECT ON A ROTOR WAKE Ph.D. Thesis - March 1985**
I. KUSMARWANTO Jun. 1985 116 p refs
(COLL-AERONAUTICS-8510) Avail: NTIS HC A06/MF A01

The effect of the ground on a rotor wake in forward flight was investigated experimentally in the working section of an 8 ft x 4 ft straight through wind tunnel. A three bladed fully articulated rotor with a solidity ratio of 0.07 and diameter of 1.06 m, powered by a hydraulilc motor, was tested at a height of 0.47 rotor diameter above a solid ground board which has a elliptical leading edge. Tests were run at various low advance ratios (less than 0.1) with two collective pitch settings. A hot wire anemometer probe was used to measure the average value of the three components of velocity. The rotor wake and the ground vortices were visualized by smoke. Both experimental results and theoretical estimates show that the ground induced interference is an upwash and a decrease in forward velocity.
Author

**N86-11188*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SHOCK FITTING APPLIED TO THE PREDICTION OF HIGH-SPEED ROTOR NOISE**
J. W. RUTHERFORD Oct. 1985 19 p refs
(NASA-TM-86781; REPT-85384; NAS 1.15:86781; USAAVSCOM-TR-85-A-8) Avail: NTIS HC A02/MF A01 CSCL 01A

A shock fitting method applied to the transonic small disturbance (TSD) potential equation is described. This method is then applied to a simple, two dimensional (2-D) rotating disturbance which is analogous to a shock radiating from the tip of a rotor blade in high speed hover. A comparison is made between the results of this method and the more standard shock capturing method. This comparison makes it clear that the effect of the results on the acoustic signature of the 2-D model is significant, and similar results can be expected when the method is extended to the three dimensional (3-D) case. Author

**N86-11189*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**USER'S MANUAL FOR A 0.3-M TCT WALL INTERFERENCE ASSESSMENT/CORRECTION PROCEDURE: 8- BY 24-INCH AIRFOIL TEST SECTION**
C. R. GUMBERT Sep. 1985 49 p refs
(NASA-TM-87582; NAS 1.15:87582) Avail: NTIS HC A03/MF A01 CSCL 01A

A transonic Wall-Interference Assessment/Correction (WIAC) procedure has been developed and verified for the 8- by 24-inch airfoil test section of the Langley 0.3-m Transonic Cryogenic Tunnel. This report is a user's manual for the correction procedure. It includes a listing of the computer procedure file as well as input for and results from a step-by-step sample case. Author

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-12011**
**ACCIDENT INVESTIGATION**
H. HOPKINS Flight International (ISSN 0015-3710), vol. 128, Sept. 28, 1985, p. 32-36.

The investigation of aircraft accidents by the Accident Investigation Board (AIB) of the United Kingdom is described. Techniques utilized by the AIB staff, such as the detecting of a flight data recorder, taking on land photographs, and performing real-time data presentation on a CRT, are explained. Investigatory organizations in other countries are discussed. The basic questions and procedures which must be conducted for all investigations are described. The problems with advanced electronic flight instrumentation are discussed. The training and credentials of the AIB staff are explained. I.F.

**N86-11190#** Air Command and Staff Coll., Maxwell AFB, Ala.
**COMING SOON TO A THEATER NEAR YOU: THE MICROWAVE LANDING SYSTEM**
K. S. C. HAMILTON Apr. 1985 23 p
(AD-A156468; ACSC-85-1025) Avail: NTIS HC A02/MF A01 CSCL 01B

This informational handbook has been prepared in response to a requirement levied by the SAC Instrument Flight Course (SIFC), Castle AFB, California. The Microwave Landing System (MLS) is projected for worldwide installation and use by both civilian and military facilities. This handbook has been developed for use in conjunction with an individualized lesson plan, prepared by the SIFC faculty. The history, development, advantages, and future projections for this excellent system are explained. The handbook is not a text for engineers, but for the pilot who is interested in safety of flight, noise abatement, and increased system confidence. The author's intent in authoring this project was to provide a brief introduction to the reasons behind the transition from Instrument Landing System (ILS) to the Microwave Landing System (MLS), and the international scope of this endeavor. Through the comparison of the operational and maintenance advantages of these two systems the author hopes to capture the interest of pilots by making them aware of the tremendous technological gains embodied in the Microwave Landing System. GRA

**N86-11191#** Federal Aviation Administration, Atlantic City, N.J. Technical Center.
**USER'S MANUAL FOR AC-20-53A PROTECTION OF AIRPLANE FUEL SYSTEMS AGAINST FUEL VAPOR IGNITION DUE TO LIGHTNING**
N. RASCH Oct. 1984 72 p
(AD-A157619; DOT/FAA/CT-83/3) Avail: NTIS HC A04/MF A01 CSCL 01B

This manual provides users of AC 20-53A, protection of aircraft fuel systems against fuel vapor ignition due to lightning, with information on the subject of fuel system lightning protection and methods of compliance of aircraft design with the Federal Aviation Regulations 23.954 and 25.954. The manual is the result of a 3-year effort requested by the FAA Technical Center of the SAE-AE4L committee which is comprised of experts in the field of lightning research and protection of aircraft and systems from the adverse effects associated with atmospheric electricity. GRA

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-10352**
**A STUDY INTO THE OPERABILITY OF RPVS IN ADVERSE WEATHER**
L. V. PARKINGTON (Royal Armament Research and Development Establishment, Fort Halstead, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 1.1-1.4.

The effect of cloud base height on the operability of an RPV is examined, taking into account the requirement for a direct line of sight (LOS) between the vehicle in the air and the ground data terminal (GDT). Cloud base height measurements carried out in Germany at quarterly intervals were curve fitted by a spline interpolation to calculate the probability of a direct LOS between the vehicle and the GDT, and RPV operability is calculated as a function of range. The mean operability was in the range 0.75-0.95, and the worst case operability at a distance of 70 kms was 0.6. The seasonal variation in operability was within 0.2 for typical operating conditions. It is concluded that the mean operability of about 0.8 should not reduce the effectiveness of RPV systems for most day/night surveillance and target acquisition applications. I.H.

**A86-10368**
**THE VEGA PORTABLE RADAR TRACKING CONTROL SYSTEM**
R. F. IRBY (Vega Precision Laboratories, Vienna, VA) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 22.1-22.8.

Some past applications of the model 657 portable radar tracking control system are described, and some recent design improvements are noted. The model 657 portable radar tracking system consists of only three major components including the antenna; radar set control; and target position display unit. Some of the design improvements incorporated into the latest version of the portable radar tracking system, model 6157, include: an increased operational range from 50 to 100 nautical miles; enhanced interference rejection by means of pulse amplitude discrimination and pulse position coding; and more data downlink channels. The new 6157 system is recommended as a tracking radar for RPV applications. Black and white photographs of the model 657 and the model 6157 radars are provided. I.H.

**A86-10370**

### DOPPLER NAVIGATION AND THE RPV

K. HOLFORD (Philips Research Laboratories, Redhill, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 24.1-24.6. Research supported by the Ministry of Defence (Procurement Executive).

The size, weight and cost of a Doppler navigator suitable for use in a RPV is dependent on the system used and the performance required. A height ceiling of a few thousand feet is substantially less than that of a normal commercial navigator and allows a simplification of the design. The unmodulated carrier type of Doppler navigator design is not, however, the most appropriate for the requirement. This paper looks at navigator construction and describes a suitable one for the RPV application. Author

**A86-11116**

### DATA LINK COMMUNICATIONS IN TACTICAL AIR COMMAND AND CONTROL SYSTEMS

C. L. GOLLIDAY, JR. (Institute for Defense Analysis, Alexandria, VA) IEEE Journal on Selected Areas in Communications (ISSN 0733-8716), vol. SAC-3, Sept. 1985, p. 779-791. DOD-sponsored research. refs

Data links in tactical air command and control systems (ACCSs) connect the computers of command and control units to one another and to weapon systems to enable rapid exchanges of real-time tactical information. This paper presents an overview description of the current and future ACCS data link architecture used by the Services and NATO. This architecture currently consists of various tactical digital information link (TADIL) standards and NATO link standards. In the near future, the Joint Tactical Information Distribution System (JTIDS) will be a major component of the architecture. While the architecture of the far future is speculative, a description of some concepts being considered, such as the role of the International Standards Organization (ISO) reference model, is presented. Author

**A86-12046**

### METHODOLOGY OF THE FLIGHT TESTING OF THE FLIGHT-CONTROL AND NAVIGATION EQUIPMENT OF AIRCRAFT AND HELICOPTERS [METODOLOGIIA LETNYKH ISPYTANI I PILOTAZHNO-NAVIGATSIONNOGO OBORUDOVANIIA SAMOLETOV I VERTOLETOV]

D.-E. P. NOVODVORSKII, G. I. POIARKOV, E. G. KHARIN, O. V. VINOGRADOV, and P. I. VLASOV Moscow, Izdatel'stvo Mashinostroenie, 1984, 136 p. In Russian. refs

The general design of the flight-control and navigation complexes of aircraft and helicopters is discussed, and the principal components of these systems are examined. Attention is then given to the structure and methods of the flight testing of flight-control and navigation systems as well as methods for the processing and analysis of flight test data. The discussion also covers the computer simulation of flight-control and navigation complexes and methods for evaluating their precision. V.L.

**A86-12300**

### TACTICAL JAMMING

A. D. ROBERTSON and F. C. PAINTER (Watkins-Johnson Co., San Jose, CA) Defense Science and Electronics (ISSN 0744-6241), vol. 4, Sept. 1985, p. 20-22, 24, 26, 28.

It is pointed out that various technological factors have combined to increase the ability of modern systems to effectively jam multiple transitory targets without seriously degrading friendly communications. Possibilities for improving jam-resistance are, therefore, considered. In this context, it is important to review the state of development of short-range VHF/UHF tactical communications systems, and the jamming devices which have been developed to defeat them. Attention is given to three electrical system design approaches commonly used to improve the antijam capabilities of communication systems, the types of jammers, time-share jamming, jamming slower systems, time-gated repeaters, and future developments. G.R.

**N86-11192#** IIT Research Inst., Annapolis, Md.

### TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM SIGNAL ENVIRONMENT MODEL (TCAS SEM) PROGRAMMER'S REFERENCE MANUAL Final Report, Aug. 1984 - Feb. 1985

C. GILCHRIST, E. WOODS, and T. KEECH Jul. 1985 169 p refs Prepared for Dept. of Defense, Annapolis
(Contract F19628-80-C-0042)
(FAA-PM-85-22; ECAC-CR-85-031) Avail: NTIS HC A08/MF A01

A traffic alert and collision avoidance system signal environment model (TCAS SEM) was developed to predict the time-average TCAS I and minimum TCAS II signal rates in a user-selected air traffic deployment. The TCAS SEM is described which includes: the modeled systems, the data-storage and retrieval subsystems for engineering data, and the software structures of all component subsystems. E.A.K.

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-10354**

### THE OPERATIONAL 'EYRIE' MULTI-ROLE ADVANCED MINI-RPV SYSTEM

M. REED (National Dynamics /Pty/, Ltd., Pinetown, Republic of South Africa) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 5.1-5.6.

The design characteristics of the Eyrie multirole returnable RPV are described. Consideration is given to the control and guidance equipment which permit the Eyrie to maintain a round-the-clock all-weather capability for real-time surveillance; electronic countermeasures; and rocket strikes against a variety of targets. The powerplant of the Eyrie consists of one 52 hp two-cylinder two-stroke engine with integral cooling. The ground control and associated tracking equipment for the Eyrie are described including the video link to ground; the command data processing hardware; and payload and weapons management systems. A series of photographs of the vehicle is provided. I.H.

**A86-10355**

### EXPERIMENTAL RPV - AN INDIAN EXPERIENCE

R. KRISHNAN, V. MITTAL, and V. DESIKAN (Aeronautical Development Establishment, Bangalore, India) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 7.1-7.11.

The design features of an Indian RPV system for civilian applications are discussed. The vehicle was built for takeoff from short runways, glider strips, or highways carrying a 10-16 lb payload. The vehicle has a high wing twin boom and pusher propeller configuration with a wing span of 3.8 m and a chord of 0.6 m. The airfoil section for the wings corresponded to a NACA 2412 profile. The powerplant for the RPV was a commercially available two cylinder piston engine of 18 hp. Control and data telemetry for the RPV was provided by a UHF FM/FDM/FM system (uplink) and a VHF/FM/FM system (downlink), with all essential flight data transmitted through the downlink. The vehicle stabilization system consisted of a vertical gyro, a heading sensor, a height hold transducer; and an air data transducer. A series of flight tests of the RPV system is described, and photographs of the vehicle in flight are provided. I.H.

**A86-10358**

### THE AUTOGYRO AS A R.P.V

W. M. FRASER (W. Vinten, Ltd., Bury Saint Edmunds, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 10.1-10.8.

The design of a remotely piloted autogyro is described. The basic airframe structure consists of a keel and rotor pylon manufactured from light alloy tubing and supported by T section light alloy extrusions. The powerplant of the autogyro is a modified four cylinder air cooled two stroke engine of 70 hp, driving a fixed two blade pusher propeller and a pre-takeoff spin up drive. The autogyro control system consisted of two servo actuators powered by 12V/5 amp batteries, and a two-axis hand controller. A push button was mounted on top of the control column for quick conversion to manual control. The system was tested during the course of one flight, and some improvements in the design of the servo actuators are recommended on the basis of the flight test results. A black and white photograph of the instrumentation panel is presented. I.H.

**A86-10365**

### DESIGN STANDARDS FOR UNMANNED AIRVEHICLES (UMAV)

P. H. MORGAN (Theta Analysis and Systems, Ltd., Camberley, England) IN: Remotely piloted venicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 18.1-18.7.

The need for a systematic approach to the design manufacture of unmanned airvehicles (UMAV) in the UK is discussed. Consideration is given to the operational requirements of UMAVs with respect to performance, operating environment, mission role. It is shown that current design requirements of the UK military for UMAVs do not require effective standardization of designs through the use of interchangeable parts, interfaces, and common power capacities. It is recommended that government authorities promulgating UMAV design requirements publish a single stand-alone version of the requirements in order to avoid ambiguity. I.H.

**A86-10374**

### CONDOR - A CANADIAN RPA FOR COMMERCIAL APPLICATIONS

G. F. TOMLINS (British Columbia Research, Vancouver, Canada) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Supplementary Papers . Bristol, University of Bristol, 1984, p. 6.1-6.7. Research supported by the Ministry of Universities, Science and Communications of the Province of British Columbia. refs

The use of remotely piloted aircraft (RPA) for environmental remote sensing is discussed. A fixed-wing model aircraft carrying a 35 mm camera was tested to gain operating experience, evaluate the usefulness of model aircraft for remote sensing, and to determine the limitations of model aircraft. Based on this experiment, general system requirements for a RPA were established; an explanation of these requirements is provided. The B.C. Research RPA program built a new RPA system, the low-cost Condor, based on a conventional puller design. The Condor system is powered by a 6.5 hp single cylinder gasoline engine that drives a 56 cm fixed pitch propeller and is easily dismantled for transportation. The control system, navigation system, sensors, and safety features of the Condor are explained. The Condor system was flight-tested and proved useful for environmental remote sensing as well as for military applications. I.F.

**A86-10566**

### IS THE 680 ROTOR BELL'S LHX CANDIDATE?

M. LAMBERT Interavia (ISSN 0020-5168), vol. 40, Sept. 1985, p. 981, 982.

Features of the prototype 680 all-composite rotor are outlined, together with tested flight qualities which make the 680 a major candidate for the U.S. Army LHX program. The 680 halves the usual number of rotor parts, eliminates heavily loaded bearings, and offers an extremely vibration-free ride, the latter a LHX requirement. Rotor life is estimated at 10,000 hr, the lifetime of a present generation helicopter. A test vehicle equipped with the 680 rotor has performed 200 km/hr dives, pulled 2.8 g, and flown half-rolls and pull-throughs. M.S.K.

**A86-10568**

### TURBOPROP AIRLINERS GET BIGGER - WILL THEY HAVE A MARKET?

B. REK Interavia (ISSN 0020-5168), vol. 40, Sept. 1985, p. 995-998.

New turboprop aircraft seating over 40 passengers are being built by European manufacturers to satisfy the demands of feeder, regional and commuter traffic. The new aircraft include the ATR42-200 44-seater, the F26 50-seater, the ATP 64-seater and the Dash 8 Series 300 50-seater. Variants of all the aircraft are also being planned, some in stretch versions and some with pressurized cabins. Much of the manufacturing activity is spurred by the growth of U.S. regional markets since deregulation. The size of the stretch turboprop aircraft is inherently limited by the overlap with small jet aircraft and their speed advantages. M.S.K.

**A86-10926#**

### LARGE AIRPLANE DERIVATIVE DEVELOPMENT METHODOLOGY

D. L. ROBINSON and M. F. MELARY (Boeing Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 14 p.
(AIAA PAPER 85-3043)

The methodology and technologies applied to design derivatives of large commercial aircraft are described. Redesigns are achieved after a five-stage process consisting of requirements definition, preliminary design, detail design and analysis, testing and qualification and product development/design refinement. All factors involved in initiating and accomplishing a new design are performed with an eye to safety as a fundamental design criteria. Decisions can then proceed on the basis of the needs of the market up to 4 yr in advance. The designs must also minimize the airlines' acquisition and operating costs while incorporating state of the art technologies and configuration flexibility. CAD has emerged as a central tool to the development and assessment process. The 747-300 design process is outlined as a case study to illustrate the procedures described. M.S.K.

**A86-10932#**

### A RAPID EVALUATION APPROACH FOR CONFIGURATION DEVELOPMENT OF NEW AIRCRAFT

Y. T. PHOA, F. CAMPISANO, P.-C. CHEN, and G. WAKAYAMA (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-3068)

Procedures followed in a computerized rapid evaluation (REV) approach to in-depth evaluations of new aircraft configurations at the early conceptual design stage are outlined. REV permits the incorporation of state of the art technology, design trade-off studies and structural design practices which lead to an optimal planform before metal cutting begins. Details of aerodynamic and structural optimization of a wing are reviewed, including the optimization codes employed in the REV CAD studies. Future extensions of the REV process to aeroelastic tailoring of entire aircraft are discussed from the point of view of the required algorithms, particularly in applications with forward swept wing aircraft. M.S.K.

**A86-10935#**

**APPROACH AND LANDING THRUST REVERSER TESTING IN GROUND EFFECT**

P. B. JOSHI (Northrop Corp., Aircraft Div., Hawthorne, CA) and M. K. COMPTON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 17 p. refs

(Contract F33615-81-C-3025)

(AIAA PAPER 85-3075)

Wind tunnel test results with a thrust reversing twin engine/twin tail scale model similar to a modified F-18 in ground proximity are reported. The trials were performed to expand the database on the thrust reversing twin engine configuration in free air. Tests were run at free air, 0.36 wing span above ground, and landing gear height. The effects of angle-of-attack, sideslip, horizontal tail deflection, rudder deflection, wing trailing edge flap angle, and landing gear were examined. Reverser-induced effects were assessed in terms of the jet/freestream dynamic pressure ratio. Data were also collected on the effects of various jet operational and placement parameters. The results are discussed with regard to aerodynamic effects, particularly at close-to-ground proximity. M.S.K.

**A86-10951#**

**DEVELOPMENT STATUS OF THE RSRA/X-WING**

R. G. GUERTIN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 7 p.

(AIAA PAPER 85-4008)

The four stages of development for the RSRA (Rotor System Research Aircraft)/X-Wing are discussed. A description of the RSRA/X-Wing is provided. The Propulsion System Test Bed (PSTB), which conducts the evaluation and qualification of the drive train and the pneumatic and the rotor components of the X-Wing system, is explained. The functions and testing of the components of the drive train, pneumodynamic, and rotor systems are described. The Vehicle Management System Laboratory (VMSL) which is used to validate the flight control computer software is discussed. The data to be provided by the wind tunnel model are described. The information from PSTB, VMSL, and wind tunnel testing will be incorporated into a ground-based data system. The aircraft is currently being prepared for the final stage of development, flight testing. I.F.

**A86-10953#**

**ENHANCING AIRCRAFT ROUGH AIRFIELD CAPABILITIES**

G. E. WALROND (USAF, Engineering and Services Center, Tyndall AFB, FL) and M. W. SKINNER (BDM Corp., McLean, VA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs

(AIAA PAPER 85-4018)

USAF research indicates a critical lack of capability for combat and airlift aircraft to operate on rough airfields. Civil engineers will be able to complete repairs and reactivate airfields more rapidly if aircraft rough airfield tolerances are increased. Research shows that coordinating the actions of aircraft undercarriage systems with aerodynamic and propulsion controls can enhance rough surface capability without sacrificing airborne performance. This paper describes the airbase wartime operational environment and a systems approach for designing new aircraft to operate in such an environment. The article is directed toward airbase planners and aircraft designers to increase information transfer regarding problems associated with bomb-damaged airfield operations. Author

**A86-10954#**

**IN-SERVICE LANDING GEAR ACTUATION SYSTEM PROBLEMS - THE SOLUTION**

W. C. COOK (Lockheed-Georgia Co., Marietta) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 6 p.

(AIAA PAPER 85-4019)

This paper describes the redesigned main landing gear actuation mechanism for the C-5B cargo aircraft and the improvements over that of the C-5A. Difficulties with the existing mechanism are corrected by replacing the entire gearbox/torque tube system with a mechanism consisting of only two gearboxes and a push rod/crank linkage. This yields substantial improvements over the original actuation system such as fail-safe synchronization between gearboxes, dual motor emergency extension, elimination of clutches in the primary drive train, and improved reliability. Author

**A86-10956#**

**AN ADHESIVELY SEALED, COMPOSITE SKINNED WING FUEL TANK**

B. J. LOGAN (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs

(AIAA PAPER 85-4023)

The development and evaluation of an adhesively sealed wing fuel tank to improve fuel containment is discussed. The adhesive sealing requires a different finish for detail parts than the conventional sealing; these various finishes are described. The benefits of using the adhesive sealing are discussed. The forward wing box design and the assembly of the wing box, which includes the attachment of the understructure assembly and upper and lower skins, are explained. The completed wing fuel tank was fuel leak tested, with cyclic pressure loading and exposure to temperature extremes, to validate the performance of the sealing. The proof test, preconditioning, test block, holding fixture, and method of leak detection are described. The test results are provided; the results revealed that the sealant provided good overall fuel containment. I.F.

**A86-10958*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A COMPUTER-ASSISTED PROCESS FOR SUPERSONIC AIRCRAFT CONCEPTUAL DESIGN**

V. S. JOHNSON (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs

(AIAA PAPER 85-4027)

Design methodology was developed and existing major computer codes were selected to carry out the conceptual design of supersonic aircraft. A computer-assisted design process resulted from linking the codes together in a logical manner to implement the design methodology. The process does not perform the conceptual design of a supersonic aircraft but it does provide the designer with increased flexibility, especially in geometry generation and manipulation. Use of the computer-assisted process for the conceptual design of an advanced technology Mach 3.5 interceptor showed the principal benefit of the process to be the ability to use a computerized geometry generator and then directly convert the geometry between formats used in the geometry code and the aerodynamics codes. Results from the interceptor study showed that a Mach 3.5 standoff interceptor with a 1000 nautical-mile mission radius and a payload of eight Phoenix missiles appears to be feasible with the advanced technologies considered. A sensitivity study showed that technologies affecting the empty weight and propulsion system would be critical in the final configuration characteristics with aerodynamics having a lesser effect for small perturbations around the baseline. Author

**A86-10960#**
**RAPID SIZING METHODS FOR AIRPLANES**
J. ROSKAM (Kansas, University, Lawrence) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 8 p.
(AIAA PAPER 85-4031)

A rapid method for preliminary weight sizing of aircraft which uses a series of logarithmic correlations between takeoff weight and empty weight is presented. The method allows rapid calculation of aircraft growth factors due to changes in mission specifications or changes in drag polar, engine specifics, payload, and empty weight. For a given mission specification, a rapid method for estimating takeoff gross weight, empty weight, and mission fuel weight is presented. The method applies to the following 12 types of aircraft: (1) homebuilts; (2) single engine props; (3) twin engine props; (4) agriculturals; (5) business jets; (6) regional turboprops; (7) transport jets; (8) military trainers; (9) fighters; (10) military patrol, bomb, and transport aircraft; (11) flying boats, amphibious, and float aircraft; (12) supersonic cruise aircraft. C.D.

**A86-10961#**
**CONFIGURATION STUDIES FOR FUEL-EFFICIENCY MAXIMISATION**
J. E. CHACKSFIELD (British Aerospace, PLC, Airframe Engineering Dept., Kingston-upon-Thames, England) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 8 p. refs
(AIAA PAPER 85-4032)

The use of Multivariate Optimization (MVO), which investigates numerous design options and varies specific parameters, to evaluate configurational changes is examined. The MVO program can handle up to 25 variables and 50 constraints for any one problem. The basic computer design and the design synthesis program, which interface to form MVO are described. The modelling technique used in MVO is explained. An example utilizing MVO to establish maximum fuel efficiency, considering various parameters, for a 40-seat commuter aircraft is presented. I.F.

**A86-10962*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**GROUND EFFECTS ON V/STOL AND STOL AIRCRAFT - A SURVEY**
J. ESHLEMEN (NASA, Ames Research Center, Moffett Field, CA) and R. E. KUHN AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 25 p. refs
(AIAA PAPER 85-4033)

The flow fields encountered by jet- and fan-powered Vertical/Short Takeoff and Landing (V/STOL) aircraft operating in ground effect are reviewed and their general effects on the aerodynamic characteristics are discussed. The ground effects considered include (1) the suckdown experienced by a single jet configuration in hover, (2) the fountain flow and additional suckdown experienced by multiple jet configurations in hover, (3) the ground vortex generated by jet and jet flap configurations in Short Takeoff and Landing (STOL) operation and the associated aerodynamic and hot-gas-ingestion effects, and (4) the change in the downwash at the tail due to ground proximity. After over 30 years of research on V/STOL aircraft, the general flow phenomena are well known and, in most areas, the effects of ground proximity can be estimated or can be determined experimentally. However, there are some anomalies in the current data base which are discussed. Author

**A86-10963#**
**GROUND EFFECT AND THE HELICOPTER - A SUMMARY**
R. W. PROUTY (Hughes Helicopters, Inc., Culver City, CA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 7 p. refs
(AIAA PAPER 85-4034)

The performance benefits and problems of a helicopter in hover and forward flight due to ground effect are examined. When the helicopter is in the hover or forward flight position the influence of the ground on flow conditions at the rotor allows for reduced power requirements; an explanation of this effect is presented. The measuring of ground effect using models and from actual flight tests is discussed. The influence of the ground effect on the ratio of induced velocities at the rotor disc during hover is graphically represented. Flying close to the ground assists in the balance of the tip vortices of the blades by allowing the induction effects of root vortices. During hover, the ground causes random yaw disturbances and turbulence is felt by observers. The negative ground effect during the transition from hover to forward flight due to increased power is explained. The influence of ground vortex on lateral control and rearward flight is described. Diagrams and graphs of the ground effect are provided. I.F.

**A86-10964#**
**UNSTEADY THRUST REVERSER EFFECTS IN GROUND PROXIMITY**
P. B. JOSHI (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs
(AIAA PAPER 85-4035)

Large and totally unexpected rolling motions observed on a thrust-reversing aircraft model in a wind tunnel operating in ground proximity are described. Time histories of the rolling moment were analyzed to determine the spectral content of the forcing functions which drive the oscillations. The analysis revealed that the forcing function contained significant energies at frequencies to which typical fighter aircraft are sensitive. The magnitude of the forcing function contained was found to be a strong function of the cant or splay angle of the lower reverser jets. Water tunnel tests confirmed that the unsteady behavior resulted from an unsteady interaction between the reverser jets and the free stream. A simplified digital simulation of aircraft motion in ground effect showed that the aircraft experienced both large roll angles and a nose-down attitude at touch-down. C.D.

**A86-10967*#** Texas A&M Univ., College Station.
**COMPARISON OF PREDICTED AND MEASURED DRAG FOR A SINGLE-ENGINE AIRPLANE**
D. T. WARD (Texas A&M University, College Station), F. C. TAYLOR, and J. T. P. DOO (Mooney Aircraft Corp., Kerrville, TX) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. Research supported by the Texas A&M University and Mooney Aircraft Corp. refs
(Contract NAG1-309)
(AIAA PAPER 85-4038)

Renewed interest in natural laminar flow (NLF) has rekindled designers' concerns that manufacturing deviations, (loss of surface contours or other surface imperfections) may destroy the effectiveness of NLF for an operational airplane. This paper reports on experimental research that compares predicted and measured boundary layer transition total drag, and two-dimensional drag coefficients for three different wing surface conditions on an airplane typical of general aviation manufacturing technology. The three flight test phases included: (1) assessment of an unpainted airframe, (2) flight tests of the same airplane after painstakingly filling and sanding the wings to design contours, and (3) similar measurements after this airplane was painted. In each flight phase, transition locations were monitored using either sublimating chemicals or pigmented oil. As expected, total drag changes were difficult to measure. Two-dimensional drag coefficients were estimated using the Eppler-Somers code and measured with a wake rake in a method very similar to Jones' pitot traverse method. The net change in two-dimensional drag was approximately 20 counts between the unpainted airplane and the 'hand-smoothed' airplane for typical cruise flight conditions. Author

**A86-10970#**
**INTEGRATED FLIGHT DATA PROCESSING SYSTEM - SUPPORT FOR THE DISCIPLINE ENGINEER**
R. M. DAVINO and D. A. FLATTERY (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs
(AIAA PAPER 85-4042)

The development of an Integrated Flight Data Processing System (IFDAPS) for real time acquisition, display, and processing of aircraft flight test data is discussed. The functions of the IFDAPS hardware components, which consist of super minicomputers and telemetry preprocessing modules in a distributed network, are described. An explanation of the interrelated computer programs in the software system, which are run file generator, acquisition display subsystem, the range control subsystem, and the control storage subsystem, is provided. The benefits of improved flight testing procedures are examined. The use of IFDAPS to evaluate aircraft performance, propulsion, stability and control, and flutter is discussed. The means by which IFDAPS architecture supports the operation through the normal preflight, real time, and postflight phases of aircraft flight testing are described. The programming of the data display formats and processing capabilities to meet specific flight testing requirements is explained. The procedures for data acquisition, display, and analysis are examined. I.F.

**A86-10974*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**A PARAMETRIC EVALUATION OF SUPERSONIC STOVL**
G. H. KIDWELL (NASA, Ames Research Center, Moffett Field, CA) and D. C. RAPP (General Dynamics Corp., Fort Worth, TX) SAE, Aerospace Vehicle Requirements Conference, Washington, DC, May 20-23, 1985. 16 p. refs
(SAE PAPER 851170)

This paper describes the results of a study to evaluate parametric variations to a single engine short-takeoff vertical-landing fighter/attack aircraft design. The variables considered involved thrust vectoring, thrust degradation, maximum lift, and other changes to determine the impact on short-takeoff performance, but subject to a vertical-landing capability. The results indicate that there are certain parameters that have a significant effect on short-field performance. Also, the optimal control strategies for transitions from a short-takeoff to forward flight and from forward flight to hover are determined. The results have applicability beyond the configuration evaluated. Author

**A86-11036#**
**PREDICTION OF FIGHTER AIRCRAFT DYNAMIC DERIVATIVES USING DIGITAL DATCOM**
W. B. BLAKE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4070)

Digital Datcom is evaluated as a design tool for predicting the dynamic derivatives of fighter aircraft. Comparisons are made with wind tunnel data, flight test results, and strip theory predictions for four modern fighter configurations. Accuracy criteria taken from prior studies are used to judge the Digital Datcom predictions. All comparisons except yaw damping are found to be within the accuracy criteria. Author

**A86-11151***
**DECENNIAL SPECIALISTS' MEETING ON ROTORCRAFT DYNAMICS, 2ND, MOFFETT FIELD, CA, NOVEMBER 7-9, 1984, PROCEEDINGS**
Meeting sponsored by the American Helicopter Society and NASA. Alexandria, VA, AHS, 1984, 342 p. For individual items see A86-11152 to A86-11174.

Various papers on helicopter rotor technology are presented. The subjects considered include: ground resonance analysis using a substructure modelling approach, aerolastic stability of a bearingless rotor, experimentally determined flutter from two and three-bladed model bearingless rotors in hover, lifting surface theory for a helicopter rotor in forward flight, aeroelastic considerations for torsionally soft rotors, and restructuring of a rotor analysis program. Also discussed are: dynamic inflow and its effect on experimental correlations, flap-lag-torsion instability in forward flight, dynamic stability of a bearingless circulation control rotor blade in hover, dynamic response characteristics of a circulation control rotor model pneumatic system, the relations between vibratory loads and airframe vibrations, coupled rotor body vibrations with in-plane degrees of freedom, helicopter vibration reduction concepts. C.D.

**A86-11152*#**
**GROUND RESONANCE ANALYSIS USING A SUBSTRUCTURE MODELING APPROACH**
S.-Y. CHEN, A. BERMAN (Kaman Aerospace Corp., Bloomfield, CT), and E. E. AUSTIN (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 9 p. refs

A convenient and versatile procedure for modeling and analyzing ground resonance phenomena is described and illustrated. A computer program is used which dynamically couples differential equations with nonlinear and time dependent coefficients. Each set of differential equations may represent a component such as a rotor, fuselage, landing gear, or a failed damper. Arbitrary combinations of such components may be formulated into a model of a system. When the coupled equations are formed, a procedure is executed which uses a Floquet analysis to determine the stability of the system. Illustrations of the use of the procedures along with the numerical examples are presented. Author

**A86-11153#**
**PARAMETRIC STUDY OF THE AEROELASTIC STABILITY OF A BEARINGLESS ROTOR**
W. E. HOOPER (Boeing Vertol Co., Philadelphia, PA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 15 p. refs

A trade study has been conducted to illustrate the sensitivity of the aeroelastic stability of a bearingless main rotor to the rotor hub coupling parameters that are available for the designer. The results are presented over the complete range of rotor speed and collective pitch available and the effects on air resonance of the 6 beam installation angles are compared together with the results of offsetting the cuff snubber attachment. The major part of the study was conducted using the FLAIR analysis which incorporates a uniform representation of the flexbeam. Results are also shown for a modified version of FLAIR in which the uniform beam is replaced by a member having the geometric tailoring resulting from structural optimization. Author

**A86-11154#**
**NONLINEAR DYNAMICS OF A HELICOPTER MODEL IN GROUND RESONANCE**
E. H. DOWELL (Duke University, Durham, NC) and D. M. TANG IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 10 p. refs
(Contract NSF MEA-83-15193)

An approximate theoretical method is presented which determines the limit cycle behavior of a helicopter model which has one or two nonlinear dampers. The relationship during unstable ground resonance oscillations between lagging motion of the blades and fuselage motion is discussed. An experiment has been carried out on using a helicopter scale model. The experimental results agree with those of the theoretical analysis. Author

**A86-11155#**

### TEST RESULTS FROM A DYNAMIC MODEL DYNAFLEX ROTOR

C. F. NIEBANCK and R. K. GOODMAN (United Technologies Corp., Sikorsky Aircraft Stratford, CT) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 10 p.

A one-fifth scale dynamic model of the Sikorsky Dynaflex rotor has been tested in hover and in forward flight conditions in the United Technologies Research Center Wind Tunnel. The Dynaflex rotor features an advanced composite structure which flexes to provide a constant speed universal joint action. Testing concentrated on confirming that the stability and dynamic response of the rotor were satisfactory. Lift conditions of up to .11 Ct/sigma and advance ratios as high as .46 were reached. Vibratory loads were comparable to those of articulated rotors. The Dynaflex rotor concept appears to be a practical concept from the standpoint of dynamic response and stability. Author

**A86-11156#**

### EXPERIMENTALLY DETERMINED FLUTTER FROM TWO- AND THREE-BLADED MODEL BEARINGLESS ROTORS IN HOVER

W. G. BOUSMAN and S. DAWSON (U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 19 p. refs

A series of experiments was performed on a 1.8-m-diam model rotor in hover for the principal purpose of investigating the lead-lag stability of isolated bearingless rotors. Incidental to those tests, at least three types of pitch-flap flutter were encountered; those flutter types constitute the subject matter of this paper. Type 1 flutter occurred approximately at the second flap-mode frequency on both two- and three-bladed rotors for both small and large pitch angles and appeared to be a classic pitch-flap flutter. Type 2 flutter showed mostly torsional motion and was seen on both two- and three-bladed rotors. The flutter mode appeared to be the rotor first-torsional mode and the flutter occurred just above 3/rev for low pitch angles. This behavior is similar to wake-excited flutter, but the flutter mode was in the wrong sense for a flutter dependent on lining up of the shed wakes. Type 3 flutter was a regressing flap flutter that occurred for only the three-bladed rotor configurations and appears to be a wake-excited flutter. Although flutter occurred on a number of different configurations, no rotor parameters were identified that were clearly stabilizing or destabilizing. Author

**A86-11158#**

### DEVELOPMENT OF AN UNSTEADY AERODYNAMICS MODEL TO IMPROVE CORRELATION OF COMPUTED BLADE STRESSES WITH TEST DATA

S. T. GANGWANI (Hughes Helicopters, Inc., Culver City, CA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 13 p. refs

A reliable rotor aeroelastic analysis operational at Hughes Helicopters, Inc. that correctly predicts the vibration levels for a helicopter is utilized for the present study to test various unsteady aerodynamics models with the objective of improving the correlation between test and theory. This analysis called Rotor Aeroelastic Vibration (RAVIB) computer program is based on a frequency domain forced response analysis which utilizes the transfer matrix techniques to model helicopter/rotor dynamic systems of varying degrees of complexity. The analysis is a nonmodal analysis and it includes effects of periodic coefficients for the forward flight conditions. The first new aerodynamics model incorporated in the analysis was based on the current state-of-art of unsteady aerodynamics. The results based on this aerodynamics model for the AH-1G helicopter rotor were compared with the flight test data during high speed operation and they indicated a reasonably good correlation for the beamwise and chordwise blade bending moments, but for torsional moments the correlation was poor. As a result, a new aerodynamics model based on unstalled synthesized data derived from the large amplitude oscillating airfoil experiments was developed and tested with RAVIB analysis. The results indicate a significant improvement in the correlation for the torsional moments. Author

**A86-11159*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AEROELASTIC CONSIDERATIONS FOR TORSIONALLY SOFT ROTORS

W. R. MANTAY (NASA, Langley Research Center, Hampton, VA) and W. T. YEAGER, JR. (U.S. Army, Structures Laboratory, Hampton, VA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 18 p. refs

A research study was initiated to systematically determine the impact of selected blade tip geometric parameters on conformable rotor performance and loads characteristics. The model articulated rotors included baseline and torsionally soft blades with interchangeable tips. Seven blade tip designs were evaluated on the baseline rotor and six tip designs were tested on the torsionally soft blades. The designs incorporated a systemmatic variation in geometric parameters including sweep, taper, and anhedral. The rotors were evaluated in the NASA Langley Transonic Dynamics Tunnel at several advance ratios, lift and propulsive force values, and tip Mach numbers. A track sensitivity study was also conducted at several advance ratios for both rotors. Based on the test results, tip parameter variations generated significant rotor performance and loads differences for both baseline and torsionally soft blades. Azimuthal variation of elastic twist generated by variations in the tip parameters strongly correlated with rotor performance and loads, but the magnitude of advancing blade elastic twist did not. In addition, fixed system vibratory loads and rotor track for potential conformable rotor candidates appears very sensitive to parametric rotor changes. Author

**A86-11160#**

### OPTICAL DESIGN APPLICATION ON THE ADVANCED AEROELASTIC ROTOR BLADE

F.-S. WEI and R. JONES (Kaman Aerospace Corp., Bloomfield, CT) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 14 p. refs

A vibration and performance optimization procedure using regression analysis has been successfully applied to an advanced aeroelastic blade design study. It is concluded that regression technique can be used in the design of future advanced aeroelastic rotor blades. Multiple optimization can be performed to evaluate the effects of various objective functions and constraint functions or to evaluate the combinations of several objective functions with different weight factors for various mission requirements. Regression technique can directly determine the sensitivity of each blade design variable and analyze the dynamic and aerodynamic effects during the entire design process. The results predicted from the regression equations for performance analysis, modal analysis, and vibration analysis are exceptionally good when compared with the C81 and Myklestad outputs. C.D.

**A86-11161#**

### DEVELOPMENT AND APPLICATION OF A TIME-HISTORY ANALYSIS FOR ROTORCRAFT DYNAMICS BASED ON A COMPONENT APPROACH

R. SOPHER and D. W. HALLOCK IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 15 p. refs

This paper describes a time-history analysis for rotoorcraft dynamics based on dynamical substructures, and non-structural mathematical and aerodynamic components. The analysis is applied to predict helicopter ground resonance and response to rotor damage. Other applications illustrate the stability and steady vibratory responses of stopped and gimballed rotors, representative of new technology. Desirable attributes expected from modern codes are realized, although the analysis does not employ a complete set of techniques identified for advanced software. The analysis is able to handle a comprehensive set of steady state and stability problems with a small library of components. It has responded to new technologies with timely solutions by limiting the effort required to implement new capabilities through its component structure. Opportunities were taken to reduce development costs by addressing more than one type of problem with a single component, such as using a minimum variance controller for trim and vibration reduction. Author

**A86-11162#**

**RESTRUCTURING THE ROTOR ANALYSIS PROGRAM C-60**

P. G. PHELAN and F. J. TARZANIN, JR. (Boeing Vertol Co., Philadelphia, PA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 13 p. refs

The 'restructuring' of the C-60 rotor analysis program in order to meet the increasing software demands of the rotary wing industry is discussed. The motivation for more capable analyses in this industry and the practical limitations of current programs are reviewed, and structured program design is examined as a solution to this problem. A development strategy for structured program design is discussed, and the restructuring process is described in detail. The current status of the restructuring of the C-60 program is addressed. C.D.

**A86-11163#**

**A REVIEW OF DYNAMIC INFLOW AND ITS EFFECT ON EXPERIMENTAL CORRELATIONS**

G. H. GAONKAR (Indian Institute of Science, Bangalore, India) and D. A. PETERS (Washington University, St. Louis, MO) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 15 p. refs

(Contract DAAG29-80-C-0092)

A review is given of the relationship between experimental data and the development of modern dynamic-inflow theory. Some of the most interesting data, first presented 10 years ago at the Dynamic Specialists' Meeting, is now reviewed in light of the newer theories. These pure blade-flapping data correlate very well with analyses that include the new dynamic inflow theory, thus verifying the theory. Experimental data are also presented for damping with coupled inplane and body motions. Although inclusion of dynamic inflow is often required to correlate this coupled data, the data cannot be used to verify any particular dynamic inflow theory due to the uncertainties in modeling the inplane degree of freedom. For verification, pure flapping is required. However, the coupled data do show that inflow is often important in such computations. Author

**A86-11164*#** California Univ., Los Angeles.

**INFLUENCE OF VARIOUS UNSTEADY AERODYNAMIC MODELS ON THE AEROMECHANICAL STABILITY OF A HELICOPTER IN GROUND RESONANCE**

P. P. FRIEDMANN and C. VENKATESAN (California, University, Los Angeles) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 12 p. refs

(Contract NAG2-209)

The aeromechanical stability of a helicopter in ground resonance was analyzed, by incorporating five different aerodynamic models in the coupled rotor/fuselage analysis. The sensitivity of the results to changes in aerodynamic modelling was carefully examined. The theoretical results were compared with experimental data and useful conclusions are drawn regarding the role of aerodynamic modeling on this aeromechanical stability problem. The aerodynamic model which provided the best all around correlation with the experimental data was identified. Author

**A86-11165*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE INFLUENCE OF DYNAMIC INFLOW AND TORSIONAL FLEXIBILITY ON ROTOR DAMPING IN FORWARD FLIGHT FROM SYMBOLICALLY GENERATED EQUATIONS**

T. S. R. REDDY and W. WARMBRODT (NASA, Ames Research Center, Moffett Field, CA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 19 p. refs

The combined effects of blade torsion and dynamic inflow on the aeroelastic stability of an elastic rotor blade in forward flight are studied. The Helicopter Equations for Stability and Loads (HESL) program is extended to derive the governing equations of motion for the blade, and a Lagrangian formulation is used to obtain the equations in generalized coordinates. The program generates the steady-state and linearized perturbation equations in symbolic form and then codes them into FORTRAN subroutines. The coefficients for each equation and for each mode are identified through a numerical program; the latter can also be used to obtain the harmonic balance equations. The governing multiblade equations are derived explicitly using HESL. These equations can accommodate any number of elastic blade modes. Stability results are presented for several hingeless rotor blade structural models, and the influence of dynamic inflow in forward flight with an elastic hingeless rotor is investigated. C.D.

**A86-11166#**

**FLAP-LAG-TORSION STABILITY IN FORWARD FLIGHT**

I. CHOPRA (Maryland, University, College Park) and B. PANDA IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 17 p. refs

An aeroelastic stability of three-degree flap-lag-torsion blade in forward flight is examined. Quasisteady aerodynamics with a dynamic inflow model is used. The nonlinear time dependent periodic blade response is calculated using an iterative procedure based on Floquet theory. The periodic perturbation equations are solved for stability using Floquet transition matrix theory as well as constant coefficient approximation in the fixed reference frame. Results are presented for both stiff-inplane and soft-inplane blade configurations. The effects of several parameters on blade stability are examined, including structural coupling, pitch-flap and pitch-lag coupling, torsion stiffness, steady inflow distribution, dynamic inflow, blade response solution and constant coefficient approximation. Author

**A86-11167#**

**DYNAMIC STABILITY OF A BEARINGLESS CIRCULATION CONTROL ROTOR BLADE IN HOVER**

I. CHOPRA (Maryland, University, College Park) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 11 p. refs

(Contract N00167-84-M-1548)

The aeroelastic stability of flap bending, lead-lag bending, and torsion of a circulation-control bearingless blade in hover is studied using a finite element formulation. The multibeams of the flexture and the outboard blade idealized as an elastic beam are discretized into beam elements, each element having 15 nodal degrees of freedom. There is a continuity of axial displacement, flap bending, lead-lag bending, and geometric twist between elements. Quasi-steady strip theory is used to evaluate aerodynamic forces. The airfoil characteristics are represented in the form of data tables. The influence of unsteady aerodynamics is introduced by using dynamic inflow modelling. The formulation is quite general for nonuniform blades. A correlation of analytical and experimental results is made for selected bearingless configurations with conventional airfoil characteristics. C.D.

**A86-11168#**

### DYNAMIC RESPONSE CHARACTERISTICS OF A CIRCULATION CONTROL ROTOR MODEL PNEUMATIC SYSTEM

C. B. WATKINS, S. K. DUTTA (Howard University, Washington, DC), and K. R. READER (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 11 p. refs

Numerical and experimental simulation of unsteady airflow through the control valve and slotted air duct of a circulation control rotor is described. The numerical analysis involves the solution of the quasi-one-dimensional compressible fluid-dynamic equations in the blade air duct together with the coupled isentropic flow equations for flow into the blade through the valve and out of the blade through the Coanda slot. Numerical solutions are compared with basic experimental results obtained for a mockup of a circulation control rotor and its pneumatic valving system. The pneumodynamic phenomena that were observed are discussed with particular emphasis on the characteristic system time lags associated with the response of the flow variables to transient and periodic control valve inputs. Author

**A86-11169#**

### AN EXAMINATION OF THE RELATIONS BETWEEN ROTOR VIBRATORY LOADS AND AIRFRAME VIBRATIONS

C. F. NIEBANCK (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 18 p. refs

Harmonic rotor hub loads and airframe interactions in steady flight are reviewed, with regard to the objective of achieving lower airframe vibration by modifying blade root loads. Flight test and wind tunnel data are reviewed, along with sample fuselage response data. Trends which could provide a generalized approach to the above objective are found to be very limited. Recent analytical and corresponding experimental blade tuning modifications are reviewed and compared. Rotor vibratory load modification and substantial vibration changes were achieved over a wide range of rotor operating conditions. It is still concluded that improvement of blade tuning has the potential for reduction in airframe vibration. Current analytical methods are found not accurate enough to confidently predict effects of blade tuning on vibration. Test-based development of favorable blade configurations is shown to be feasible, and will also generate data to guide further development of analytical methods. Author

**A86-11170*#** Boeing Vertol Co., Philadelphia, Pa.

### PLANNING, CREATING AND DOCUMENTING A NASTRAN FINITE ELEMENT MODEL OF A MODERN-HELICOPTER

R. GABEL, D. REED, R. RICKS, and W. KESACK (Boeing Vertol Co., Philadelphia, PA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 17 p. refs
(Contract NAS1-16460)

Mathematical models based on the finite element method of structural analysis as embodied in the NASTRAN computer code are widely used by the helicopter industry to calculate static internal loads and vibration of airframe structure. The internal loads are routinely used for sizing structural members. The vibration predictions are not yet relied on during design. NASA's Langley Research Center sponsored a program to conduct an application of the finite element method with emphasis on predicting structural vibration. The Army/Boeing CH-47D helicopter was used as the modeling subject. The objective was used to engender the needed trust in vibration predictions using these models and establish a body of modeling guides which would enable confident future prediction of airframe vibration as part of the regular design process. Author

**A86-11171#**

### COUPLED ROTOR-BODY VIBRATIONS WITH INPLANE DEGREES OF FREEDOM

M.-S. HUANG and D. A. PETERS (Washington University, St. Louis, MO) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 15 p. refs
(Contract DAAG29-80-C-0092)

In an effort to understand the vibration mechanisms of helicopters, the following basic studies are considered. A coupled rotor-fuselage vibration analysis including inplane degrees of freedom of both rotor and airframe is performed by matching of rotor and fuselage impedances at the hub. A rigid blade model including hub motion is used to set up the rotor flaplag equations. For the airframe, 9 degrees of freedom and hub offsets are used. The equations are solved by harmonic balance. For a 4-bladed rotor, the coupled responses and hub loads are calculated for various parameters in forward flight. The results show that the addition of inplane degrees of freedom does not significantly affect the vertical vibrations for the cases considered, and that inplane vibrations have similar resonance trends as do flapping vibrations. Author

**A86-11172*#** United Technologies Research Center, East Hartford, Conn.

### ANALYSIS OF POTENTIAL HELICOPTER VIBRATION REDUCTION CONCEPTS

A. J. LANDGREBE and M. W. DAVIS (United Technologies Research Center, East Hartford, CT) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 19 p. Research supported by the United Technologies Corp., U.S. Army, and NASA. refs

Several recent helicopter vibration reduction research programs are described. Results of studies of blade design parameters in rotor vibratory response and of an advanced blade design for reduced vibration are examined. An optimization approach to develop a general automated procedure for rotor blade design is described, and analytical results for an articulated rotor operating at a steady 160 kt flight condition are reported. The use of a self-adaptive controller to implement higher harmonic control in closed-loop fashion is addressed, and a computer simulation used to evaluate and compare the performance of alternative algorithms included in the generic active controller is discussed. Results are presented for steady level flight conditions, short-duration maneuvers, blade stresses and rotor performance, blade-appended aeroelastic devices, vibratory airloads, wake-induced blade airloads, and airloads from blade motions, the interaction of rotor and fuselage, and the interaction of rotor and empennage. C.D.

**A86-11173#**

### ADAPTATION OF A MODERN MEDIUM HELICOPTER (SIKORSKY S-76) TO HIGHER HARMONIC CONTROL

J. J. OLEARY, S. B. R. KOTTAPALLI (United Technologies Corp., Sikorsky Aircraft, Stratford, CT), and M. DAVIS (United Technologies Research Center, East Hartford, CT) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 13 p. refs

Sikorsky Aircraft has performed analytical studies, design analysis risk reduction tests for Higher Harmonic Control on the S-76, an 8-10,000 lb helicopter which cruises at 145 kts. Flight test hardware has been assembled, main servo frequency response tested and upgraded, aircraft control system shake-tested and verified, open loop controllers designed and fabricated, closed loop controllers defined and evaluated, and rotors turning ground and flight tests planned for the near future. Open loop analysis shows that about 2 deg of higher harmonic feathering at the blade 75 percent radius will be required to eliminate 4P vibration in the cockpit. Analytical computer simulations of a closed loop controller have been evaluated relative to the theses of reducing vibration to low levels while maintaining good ride quality and aircraft structural stress attributes. The analytical results, design concepts, program approach, and risk reduction tests are reviewed. Author

**A86-11607#**

### VISCOUS DRAG REDUCTION WITH MICROPOROUS-FACED HONEYCOMB SANDWICH FOR MODERN TURBOFAN INSTALLATIONS

J. S. MOUNT and T.-M. LIU (Rohr Industries, Inc., Chula Vista, CA) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 56-63. refs

The advantages of a structural/acoustic honeycomb sandwich using woven-wire microporous face sheet are examined from the acoustical standpoint. It is shown experimentally that such a sandwich structure is characterized by low drag under duct turbulent flow conditions. A new general mathematical approach linking acoustical and drag properties is then presented. Finally, a nacelle concept is described which uses suction through this type of structure to reduce drag by maintaining laminar flow over the nacelle surface. V.L.

**A86-11614#**

### PERFORMANCE OF A TOP-MOUNTED INLET SYSTEM APPLIED ON TWO COMBAT AIRCRAFT CONCEPTS

K. WIDING (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 135-148.

The wind tunnel testing of a top-mounted inlet design on attacker and fighter aircraft models is discussed. The advantages of a top-mounted inlet design are explained. The attacker and fighter model configurations are described. The attacker model was tested in a low speed wind tunnel at a Mach number of 0.18 and the fighter model was in a transonic-supersonic wind tunnel with Mach numbers ranging from 0.50-1.18. The techniques ued for data acquisition are explained. The results for total pressure losses, steady state distortion indices, and the turbulence index are discussed and graphs are presented. The effects of strakes, central wall, and sideslip on performance is graphically explained. I.F.

**A86-11883**

### OPTIMIZATION OF AIRPLANE WING STRUCTURES UNDER GUST LOADS

S. S. RAO (San Diego State University, CA) Computers and Structures (ISSN 0045-7949), vol. 21, no. 4, 1985, p. 741-749. refs

A methodology is presented for the optimum design of aircraft wing structures subjected to gust loads. The equations of motion, in the form of coupled integro-differential equations, are solved numerically and the stresses in the aircraft wing structure are found for a discrete gust encounter. The gust is assumed to be one minus cosine type and uniform along the span of the wing. In order to find the behavior of the wing structure under gust loads and also to obtain a physical insight into the nature of the optimum solution, the design of the typical section (symmetric double wedge airfoil) is studied by using a graphical procedure. Then a more realistic wing optimization problem is formulated as a constrained nonlinear programming problem based on finite element modeling and the optimum solution is found by using the interior penalty function method. A sensitivity analysis is conducted to find the effects of changes in design variables about the optimum point on the response quantities of the wing structure. Author

**A86-11945**

### DEVELOPMENT AND APPLICATION OF MATHEMATICAL MODELS OF AIRCRAFT [SOZDANIE I PRIMENENIE MATEMATICHESKIKH MODELEI SAMOLETOV]

A. S. BELOTSERKOVSKII, B. O. KACHANOV, IU. B. KULIFEEV, and V. I. MOROZOV Moscow, Izdatel'stvo Nauka, 1984, 144 p. In Russian. refs

The book is concerned with the mathematical modeling of the motion of aircraft and with the use of mathematical models for studying the aerodynamic and dynamic aircraft characteristics. Attention is given to current models of flutter and methods of flutter analysis with allowance for the nonstationary nature of flow. Models are examined which allow for the elasticity of the structure, various cargo arrangements, effects of the control system, and external perturbations. Examples illustrating the usefulness of mathematical modeling in studying the dynamics of aircraft and in improving the efficiency of onboard equipment are presented. V.L.

**A86-11958**

### RUNWAY AND MANEUVERING PERFORMANCE ENHANCED

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Oct. 1985, p. 12-18.

The U.S. Air Force has investigated approaches which might be used to minimize the degraded operational capability resulting from battle damaged runways. Some of these approaches involve a modification of the aircraft to make an operation from minimum operating strips possible. Until very recently, short takeoff and landing (STOL) tactical fighters were not considered feasible. However, the F-15 STOL demonstrator offers now the possibility of both enhanced maneuverability and improved takeoff and landing performance on the basis of a use of essentially the same devices. An American aerospace company is modifying a standard, two-seat F-15B fighter to investigate several technology areas which may achieve that two-fold objective. Aircraft modifications related to two-dimensional nozzles and canards, and to thrust vectoring are discussed. G.R.

**A86-11959**

### HIGH ANGLE OF ATTACK MANEUVERING PROBED

D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 5, Oct. 1985, p. 20-22.

Extreme flight envelope research is particularly important for high-performance fighter aircraft which can fly in these regimes. Thus, problems arise in connection with aircraft which are to fly at high angles of attack (plus 70 degrees) and at high yaw rates. Such aircraft are susceptible to entering into a spin. In order to deal with these problems, a new program which involves high angle of attack research is being prepared. One of the early phases of this program will be concerned with obtaining a design methodology which will enable the design engineer to correlate in an accurate manner wind tunnel data in the high angle of attack regime with actual flight test data. A second phase of the program will deal with the actual flight testing of a high performance aircraft in the extreme areas of the flight envelope. G.R.

**A86-11960**

### OBLIQUE WING - NEW APPROACH TO AN OLD PROBLEM

D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 5, Oct. 1985, p. 26-29.

Improvements in aircraft efficiency involve in practice the employment of approaches to reduce the drag. One popular approach involves the use of a variable wing sweep. A NASA program is now concerned with an improved way to achieve variable sweep. This program is referred to as the 'oblique wing research aircraft' (OWRA) program. The oblique wing concept was first explored in the 1940s. Studies conducted by NASA include wind tunnel tests with an aircraft constructed of foam and fiberglass. The results from various investigations have been so promising that NASA and the Navy have entered into a joint research program to resolve remaining uncertainties. If this program is successful, the option to use the oblique wing will be made available in the 1990s. G.R.

**A86-11961**

### OPTIMUM WING - FOR ALL FLIGHT CONDITIONS?

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Oct. 1985, p. 36-40.

The present paper is concerned with a mission adaptive wing which will automatically adjust its camber to achieve optimum performance throughout the flight envelope. It is pointed out that such a wing is nearing reality. The mission adaptive wing (MAW) installed on the AFTI/F-111 (Advanced Fighter Technology Integration) test bed will soon be proving the concept. Eventually, the mission adaptive wing will operate in four automatic modes, each of which can be selected individually or combined. These modes include the 'cruise camber control', the 'maneuver camber control', the 'maneuver load control', and the 'maneuver enhancement and gust control mode'. G.R.

**A86-12008**
**JETSTAR SMOOTHES THE WAY**
G. WARWICK Flight International (ISSN 0015-3710), vol. 128, Sept. 21, 1985, p. 32-34.

The development of laminar flow control technology by NASA is examined. Advances which have led to reduced fuel consumption and cost are discussed. The use of laminar flow control to reduce skin-friction drag 25-40 percent is explained. The two test sections developed to evaluate laminar flows, the suction technique used to provide laminar flow control, and the procedure utilized for protection against insects are described. The test aircraft, JetStar, is provided with a Kollenberg probe, a charge patch, and a cockpit display; the instruments functions are explained. The testing of the aircraft in simulated airline operations is described. The use of the F-14 to collect data on pressure distributions over laminar flow aerofoils at different sweep angles, and a DC-9-sized test bed to display suction over the wing leading-edge using the laminar flow aerofoil section to maintain laminar flow is examined. I.F.

**A86-12009**
**B-1B - BORN AGAIN BOMBER**
N. LYNN Flight International (ISSN 0015-3710), vol. 128, Sept. 21, 1985, p. 39-42.

The development of the B-1B bomber is discussed. The production and delivery schedule, and the flight testing of the aircraft are described. The crash of the B-1A aircraft and the new warning light system developed after the crash are explained. The stability enhancement function added to the stability control augmentation system, and the stall inhibitor system added to the aircraft are examined. An example of foreign object damage to the flapper doors of the B-1B bomber is provided. The offensive avionics system is explained and its proposed production and delivery schedule are given. I.F.

**A86-12013**
**AHRENS TO BUILD TURBOPROP-POWERED TRANSPORT PROTOTYPES IN SWEDEN**
D. A. BROWN Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Oct. 7, 1985, p. 61, 62, 64, 69.

The present article is concerned with the KM-180 four-turboprop transport which is being developed by the former head of an American aerospace company. The 40-seat aircraft has been designed as a low-cost, slow-speed, unpressurized transport which can be used profitably by major air carriers on routes on which now 25 persons are carried by a 737. The KM-180 is limited to 200 kt., and has a relatively short range. It is expected that airlines will be able to use the aircraft to provide feeder service on routes which do not provide sufficient traffic to warrant the cost of a jet operation or even a pressurized turboprop. Thus, it would take about 45 min. To fly the route from Malmo to Hamburg, West Germany, in the KM-180. G.R.

**A86-12530**
**A TECHNICAL-ECONOMICAL ANALYSIS OF AIRSHIPS OF VARIOUS SIZES, SHAPES, AND GAS PERMEABILITY OF THE SHELL [TEKHNIKO-EKONOMICHESKII ANALIZ DIRIZHABLEI RAZLICHNYKH RAZMEROV, FORM I GAZOPRONITSAEMOSTI OBOLOCHEK]**
E. V. GOLDOBEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 18-21. In Russian.

Dimensions and performance characteristics are presented for helium airships, and the effect of the aspect ratio of the airship on its mass and aerodynamic characteristics is discussed. A model is then presented for assessing the specific cost (cost per unit area) of aluminum airship shells with a reinforcing structure. Expressions are also presented for calculating the cost effectiveness of airship operation with allowance for the gas permeability of the shell. V.L.

**A86-12545**
**CHARACTERISTICS OF THE DESIGN AND FABRICATION OF LARGE AIRCRAFT COMPONENTS IN COMPOSITE MATERIALS [OSOBENNOSTI PROEKTIROVANIIA I IZGOTOVLENIIA KRUPNOGABARITNYKH AGREGATOV LETATEL'NYKH APPARATOV IZ KOMPOZITSIONNYKH MATERIALOV]**
A. A. DUDCHENKO, V. I. REZNICHENKO, V. A. KOZLOV, and O. N. KOCHETKOVA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 77-79. In Russian.

A procedure for the design of thin-walled reinforced composite structures of the wing and tail unit type is presented. The approach used here involves separating the stress-strain state into the main, slowly varying stress-strain state and the edge effect. The main stress-strain state is analyzed using an updated version of the beam theory; the edge effect is treated on the basis of the Vlasov method. The design procedure is illustrated by a specific example. V.L.

**N86-10004#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**OPTIMUM DESIGN OF AN AIRCRAFT WING STRUCTURE WITH MULTIPLE CONSTRAINTS BY THE DIRECT-VISION CRITERIA METHOD**
L. LINANG (Shenyang Aircraft Corp.) *In its* Acta Aeron. et Astronautica Sinica (FTD-ID(RS)T-1120-84) p 34-52 4 Oct. 1984 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 4, 1983 p 39-47
Avail: NTIS HC A04/MF A01 CSCL 01A

An optimized computer program (SAFDOP) is introduced which uses the direct vision criteria method for a wing surface structure with multiple constraints. This program can separately carry out analysis, optimization and synthetic optimization calculations of stress, displacement, flutter and static aeroelasticity. The alternate constraint method was used for synthetic optimization calculations. Aside from the stress constraints using the full stress method, each of the other constraints used the uniform derivative criteria. For practical purposes, the element linking weight was used as an independent design variable, in the optimum design the automatic sieve selection design variable and other methods were used and the automatic generation of initial numerical data was considered. This program was used to calculate a typical fighter wing and it proved to be feasible. Author

**N86-10032** Department of the Air Force, Washington, D.C.
**ATTACHMENT METHOD-CERAMIC RADOME TO METAL BODY Patent**
J. S. PERRY, inventor (to Air Force) 28 May 1985 6 p
Supersedes AD-D010270
(AD-D011778; US-PATENT-4,520,364;
US-PATENT-APPL-SN-486603; US-PATENT-CLASS-343-872)
Avail: US Patent and Trademark Office CSCL 13H

A radome assembly for an airframe and a method for attaching the assembly to an airframe are provided. The radome assembly comprises a ceramic shell with a polymeric transition section bonded thereto, which shell is adapted for mounting to a metal airframe. The transition section has a coefficient of thermal expansion intermediate between that of the ceramic shell and that of the metal airframe. The method of this invention comprises preloading the transition section in circumferential compression when the radome assembly is attached to the airframe. Author (GRA)

**N86-10033*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.
**A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs
(Contract NAG1-300)
(NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated. Author

**N86-10034#** Air Command and Staff Coll., Maxwell AFB, Ala.
**THE DIRIGIBLE: A CATALYST FOR RESOURCE EXPLOITATION IN REMOTE AREAS?**
J. C. MURPHY Apr. 1985 80 p
(AD-A156518; ACSC-85-1950) Avail: NTIS HC A05/MF A01 CSCL 01C

Many developing nations have considerable wealth in natural resources, but are unable to exploit it. Located in remote areas, the countries simply cannot afford to invest the enormous amounts required to build roads, railroads, or airfields to access the regions. The dirigible--modern day blimp--offers a potentially inexpensive, flexible, and capable method of of transporting minerals, timber, or crops in areas without traditional transportation support. Even more important, they can stimulate agricultural or industrial development a significant distance from principal roads thereby unlocking the wealth of the land for a nation. The airship can be the catalyst for colonization at the same time it strengthens the economy. This study provides a cost/benefit model to evaluate the relative benefits of different transportation systems in the exploitation of resources. Author (GRA)

**N86-10035#** Naval Postgraduate School, Monterey, Calif.
**CONSTRUCTION AND USE OF A RADIO CONTROLLED MODEL HELICOPTER FOR RESEARCH M.S. Thesis**
C. J. HINTZE Mar. 1985 67 p
(AD-A156547) Avail: NTIS HC A04/MF A01 CSCL 01C

This thesis examines the relationship that exists between a radio controlled model helicopter and a full-size helicopter. The construction of a radio controlled model helicopter and flight training involved is discussed. Initial hover performance testing of a radio controlled helicopter is evaluated. Author (GRA)

**N86-10036#** Aeronautical Research Labs., Melbourne (Australia).
**A REVIEW OF AUSTRALIAN INVESTIGATIONS ON AERONAUTICAL FATIGUE DURING THE PERIOD APRIL 1983 TO MARCH 1985**
G. S. JOST Mar. 1985 93 p
(AD-A156602; ARL/STRUC-TM-399) Avail: NTIS HC A05/MF A01 CSCL 01C

A summary is presented of the aircraft fatigue research and associated activities which form part of the programs of the Aeronautical Research Laboratories, the Department of Aviation and the Australian aircraft industry. The major topics discussed include the fatigue of both civil and military aircraft structures, fatigue damage detection, analysis and repair and fatigue life monitoring and assessment. Author (GRA)

**N86-10038#** Air Command and Staff Coll., Maxwell AFB, Ala.
**RETROFIT OF SAC EC-135C AND RC-135 AIRCRAFT WITH CFM-56 ENGINES**
W. N. STOOKE, JR. Apr. 1985 42 p
(AD-A156688; ACSC-85-2630) Avail: NTIS HC A03/MF A01 CSCL 15E

This report is an analysis of the advantages and disadvantages of retrofitting SAC's EC-135C and RC-135 fleet with the CFM-56 engine package being used to convert the KC-135As to KC-135Rs. It reviews selected components of the modification package and compares the performance capabilities of current and modified aircraft during takeoff, cruise, receiver aerial refueling, and landing. The projected fuel savings on the investment dollar are calculated in Af Regulation 173-13, USAF Cost and Planning Factors, and could pay for the retrofit of the 31 aircraft in 18 years. Finally, the advantage of logistics commonality among all three aircraft is assessed. GRA

**N86-10039#** Aeronautical Research Labs., Melbourne (Australia).
**PROPOSED MODIFICATIONS FOR THE RAAF AIRTRAINER CT-4A COCKPIT**
K. W. ANDERSON and K. C. HENDY Dec. 1984 23 p
(AD-A156808; ARL/SYS-TM-75) Avail: NTIS HC A02/MF A01 CSCL 01C

The design of the CT-4A Airtrainer cockpit is known to breach numerous ergonomics principles and several ASCC Air Standards. As a result, pilots report problems such as inadequate reach envelopes and obstruction of the control column by the left pilot's left knee. Consequently, the RAAF asked ARL to study the cockpit design and recommend simple changes. An anthropometric model was developed and used to evaluate several patterns of seat adjustment. The best of these (a ramp at 40 degrees to the fuselage reference line) was evaluated in practical trials with an experimental seat in a CT-4A fuselage. For each of the thirty pilot subjects, a sitting position with acceptable view, reach and clearance was found with the experimental arrangement. The ARL recommendations for cockpit modifications include: a smaller left side throttle quadrant with external pushrods, a seat adjustable along a 40 degree ramp, improved instrument lighting, pedals moved forwards, control column modifications, lowered lap belt anchor points, dual fuel gauges and a center transponder location. Incorporation of these recommendations is expected to enhance training effectiveness and improve flying safety. GRA

**N86-10040#** Air Command and Staff Coll., Maxwell AFB, Ala.
**THE QUEST FOR A HELICOPTER SUITABLE FOR COMBAT RESCUE, 1967 - 1983**
T. O. JAHNKE Apr. 1985 30 p
(AD-A156842; AD-E301723; ACSC-85-1330) Avail: NTIS HC A03/MF A01 CSCL 01C

This paper provides a concise, historical perspective of the quest for a helicopter suitable for combat rescue. Concentrating on the period 1967 to 1983, this report looks at the historical development, roles and missions, and analyzes the selection process of four different combat rescue helicopters. The study concludes that the unique mission requirements of combat rescue require aircraft designed from the ground on as pure rescue helicopters. Author (GRA)

**N86-10041#** Naval Postgraduate School, Monterey, Calif.
**A COMPARATIVE ANALYSIS OF A CV HELICOPTER AND A JVX (JOINT SERVICES ADVANCED VERTICAL LIFT) TILT-ROTOR AIRCRAFT IN AN AIRCRAFT CARRIER BASED ASW (ANTI-SUBMARINE WARFARE) M.S. Thesis**
R. L. WILDE Mar. 1985 134 p
(AD-A156871) Avail: NTIS HC A07/MF A01 CSCL 01C

This thesis analyzes the environmental compatibility and the potential performance capabilities of two proposed types of vertical flight capable aircraft in an aircraft carrier Anti-Submarine role. The aircraft compared are the CV Helicopter(SH-60F) and an ASW variant of the Joint Services Advanced Vertical Lift (JVX) tilt-rotor aircraft. This thesis compares their adaptability and relative expected mission effectiveness by analyzing their physical dimensions and characteristics and their projected flight performance parameters. Their expected performance in a specific scenario, an ASW pouncer mission employing active dipping sonar, is analyzed using a simulation model. GRA

**N86-10042*#** Texas Technological Univ., Lubbock. Dept. of Electrical Engineering.

**ELECTROMAGNETIC RESONANCES OF CYLINDERS AND AIRCRAFT MODEL WITH RESISTIVE WIRES Final Report, Apr. 1983 - Apr. 1984**

G. W. WOOD and T. F. TROST Apr. 1985 61 p
(Contract NAG1-28; DA PROJ. 376-3)
(NASA-CR-176250; NAS 1.26:176250; AD-A156960; AFWL-TR-84-90) Avail: NTIS HC A04/MF A01 CSCL 01C

Laboratory experiments were done to determine the natural frequencies of the electromagnetic resonances of conducting bodies with attached wires. The bodies include two cylinders and an approximate scale model of the NASA F-106B aircraft. All are three feet in length. Time-domain waveforms of B-dot and D-dot were obtained from a sampling oscilloscope, and Prony analysis was used to extract the natural frequencies. This work is an extension of previous work, but smaller, more resistive wires have been used. The first four natural frequencies of the cylinders (and wires) were determined, and a comparison with calculated results of other investigators show reasonable agreement. Seven natural frequencies were determined for the F-106B model (wire wires), and these have been compared with results obtained by NASA in 1982 during direct lightning strikes to the aircraft. The agreement between the corresponding natural frequencies of the model and the aircraft is fairly good and is better than that obtained in the previous work using wires with less resistance. The frequencies lie between 6.5 MHz and 41 MHz, and all of the normalized damping rates are between 0.14 and 0.27. GRA

**N86-10043#** European Space Agency, Paris (France).

**SYSTEM MODELING AND IDENTIFICATION OF EQUIVALENT SYSTEMS WITH AND WITHOUT COMPENSATING TIME DELAY FOR CONTROL-AUGMENTED AIRCRAFT**

J. SKUDRIDAKIS Oct. 1985 104 p refs Transl. into ENGLISH of "Systemmodellierung und Identifizierung von aequivalenten' Systemen mit und ohne Ersatztotleit fuer reglergestuetzte Flugzeuge' Rept. DFVLR-FB-83-36, DFVLR, Brunswick, 1983 Original language document was previously announced as N84-24570
(ESA-TT-852; DFVLR-FB-83-36) Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne DM 34

The identification of the aerodynamic and equivalent derivatives in the longitudinal and lateral motions of modern fighter aircraft is described. Determination of handling qualities parameters through reduced evaluation methods in order to fulfill the requirements of the MIL-F-8785 C calculation is discussed. To accomplish that goal, the highly complex method of observing aircraft motion was reduced by goal-oriented simplifications to a lower order system. The mathematical modeling for various control inputs with and without compensating time-delay, their influence on the results, and their accuracy are outlined. Author (ESA)

**N86-10044#** Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).

**REVIEW OF INVESTIGATIONS ON AERONAUTICAL FATIGUE IN THE FEDERAL REPUBLIC OF GERMANY Review Period, May 1983 - April 1985**

O. BUXBAUM and H. HUTH 1985 86 p refs Presented at 19th Intern. Comm. on Aeron. Fatigue (ICAF) Conf., Pisa, 1985
(LBF-S-173; ISSN-0721-5320) Avail: NTIS HC A05/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 95

Measurement and analysis of operational loads on aircraft; metal fatigue (notch strength, low cycle fatigue, crack propagation and fracture mechanics); composites (fatigue, environmental influences, damage mechanisms); joints; fatigue life prediction; and component and full scale tests are summarized. Author (ESA)

**N86-10045#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**FATIGUE, STATIC TENSILE STRENGTH AND STRESS CORROSION OF AIRCRAFT MATERIALS AND STRUCTURES**

J. SCHIJVE Oct. 1982 203 p refs Presented at Summer School Course, Bandung, Indonesia, Aug. 1982 Sponsored by Netherlands and Indonesian Governments
(VTH-LR-360-PT-1) Avail: NTIS HC A10/MF A01

Failure modes in aircraft structures; stress concentration at notches; plastic deformation and residual stress; stress intensity factors of cracks; failure in tension; stress corrosion; material fatigue; fatigue under constant and variable amplitude loading; joint fatigue; fatigue loads on aircraft structures; and fatigue of aircraft structures are discussed. Author (ESA)

**N86-11181#** Joint Publications Research Service, Arlington, Va.

**WORLD'S LARGEST AIRPLANE NOW BEING TESTED**

N. DOMBKOVSKIY *In its* USSR Rept.: Transportation (JPRS-UTR-85-011) p 17-20 7 Oct. 1985 Transl. into ENGLISH from TRUD (Moscow), 23 May 1985 p 3
Avail: NTIS HC A06

Unique design features of the newly developed AN-124 aircraft are described. Factors such as weight, cargo capacity, and wing configuration are discussed. Problems encountered in the construction of the AN-124 are also discussed. B.W.

**N86-11194*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EXPERT SYSTEMS DEVELOPMENT AND APPLICATION**

E. L. DUKE and V. A. REGENIE Oct. 1985 8 p Presented at the IEEE Symp. on Expert Systems in Govt., McLean, Va., 23-25 Oct. 1985
(NASA-TM-86746; H-1310; NAS 1.15:86746) Avail: NTIS HC A02/MF A01 CSCL 01C

Current research in the application of expert systems to problems in the flight research environment is discussed. In what is anticipated to be a broad research area, a real time expert system flight status monitor has been identified as the initial project. This real time expert system flight status monitor is described in terms of concept, application, development, and schedule. Author

**N86-11195*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DESCRIPTION OF AN EXPERIMENTAL EXPERT SYSTEM FLIGHT STATUS MONITOR**

E. L. DUKE and V. A. REGENIE Oct. 1985 11 p refs Presented at the 5th AIAA Computers in Aerospace Conf., Long Beach, Calif., 21-23 Oct. 1985
(NASA-TM-86791; H-1317; NAS 1.15:86791; AIAA-85-6042-CP) Avail: NTIS HC A02/MF A01 CSCL 01C

This paper describes an experimental version of an expert system flight status monitor being developed at the Dryden Flight Research Facility of the NASA Ames Research Center. This experimental expert system flight status monitor (ESSFSM) is supported by a specialized knowledge acquisition tool that provides the user with a powerful and easy-to-use documentation and rule construction tool. The EESFSM is designed to be a testbed for concepts in rules, inference mechanisms, and knowledge structures to be used in a real-time expert system flight status monitor that will monitor the health and status of the flight control system of state-of-the-art, high-performance, research aircraft. Author

**N86-11196*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**COMPARISON OF CALCULATED AND MEASURED VELOCITIES NEAR THE TIP OF A MODEL ROTOR BLADE AT TRANSONIC SPEEDS**
M. E. TAUBER, F. K. OWEN (Complere, Inc.), R. G. LANGHI (Informatics General Corp., Palo Alto, Calif.), and G. E. PALMER Aug. 1985 81 p refs
(NASA-TM-86697; REPT-85158; NAS 1.15:86697) Avail: NTIS HC A05/MF A01 CSCL 01C

The ability of the ROT22 code to predict accurately the transonic flow field in the crucial region around and beyond the tip of a high speed rotor blade was assessed. The computations were compared with extensive laser velocimetry measurements made at zero advance ratio and tip Mach numbers of 0.85, 0.88, 0.90, and 0.95. The comparison between theory and experiment was made using 300 scans for the three orthogonal velocity components covering a volume having a height of over one blade chord, a width of nearly two chords, and a length ranging from about 1 to 1.6 chords, depending on the tip speeds. The good agreement between the calculated and measured velocities established the ability of the code to predict the off blade flow field at high tip speeds. This supplements previous comparisons where surface pressures were shown to be well predicted on two different tips at advance ratios to 0.45, especially at the critical 90 deg azimuth blade position. These results demonstrate that the ROT22 code can be used with confidence to predict the important tip region flow field including the occurrence, strength, and location of shock waves causing high drag and noise. Author

**N86-11197#** Air Command and Staff Coll., Maxwell AFB, Ala.
**EVALUATION OF FAULT REPORTING/FAULT ISOLATION FOR F-15 AIRCRAFT**
C. A. MUSSARI Apr. 1985 26 p
(AD-A156516; ACSC-85-1955) Avail: NTIS HC A03/MF A01 CSCL 01C

The author set out to see if the accuracy of the FR/FI manuals is a factor in their non-use. Accuracy of the manuals was determined by analyzing actual reported inflight discrepancies. Fault code accuracy was obtained by comparing each discrepancy as written on the TAC Form 122 (Debriefing Record) with the discrepancy depicted in the FR manual. Accuracy of repair actions was obtained by tracking the repair action recommended by the fault isolation manual and comparing it with that shown on the TAC Form 122. Analysis revealed the F-15 fault reporting manual can accurately represent a random inflight malfunction 83.8% of the time, and these malfunctions can be accurately isolated in the fault isolation manual 77.7% of the time. These accuracy levels are acceptable and not a major factor in the non-use of the manuals. Observation of the debriefing and maintenance process, and interviews with aircrews and maintenance technicians, revealed a general lack of understanding and confidence in the FR/FI system. This lack of understanding and confidence, exhibited by both aircrews and maintenance personnel is the primary reason for the system's non-use. Recommended actions to show the effectiveness of using the system as designed are provided. GRA

**N86-11198#** Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
**A COMPARISON OF THE NAVTOLAND (NAVY VERTICAL TAKEOFF AND LANDING) SH-2F HELICOPTER MODEL WITH THE REQUIREMENTS OF MIL-H-8501A AND WITH FLIGHT DATA Final Report**
R. L. NAVE 31 Jan. 1984 78 p
(Contract F41-400)
(AD-A157297; NADC-84166-60) Avail: NTIS HC A05/MF A01 CSCL 01D

This report compares the dynamic response characteristics of an SH-2F simulator model with available flight test data and with the requirements of MIL-H-8501A, Helicopter Flying and Ground Handling Qualities; General Requirements for. The Navy Vertical Takeoff and Landing (NAVTOLAND) simulator model was developed to facilitate the design of an automatic approach and landing guidance control systems for helicopters and V/STOL aircraft. The simulation was validated by comparing the model response with all available flight test data. In addition, the model was used to examine some of the requirements of MIL-H-8501A. Considerable insight was gained in the application of the specification and in understanding techniques needed to determine compliance with the requirements. The original model was developed and installed on the NASA Ames Vertical Motion Simulator. Numerous modifications were made to the software based on test pilot evaluations. A version of this simulation model including all empirical adjustments was installed on the NAVAIRDEVCEN computer system. Further evaluation of the model was carried out using this batch version of the helicopter model. This study found that it is difficult if not impossible to satisfactorily tune a helicopter simulation based on pilot opinions without a complete flight test data base. The requirements of MIL-H-8501A need to be defined in more detail and in some cases be revised. An altitude excursion limit should be added to the current quick stop maneuver. Analysis indicates that the current 2-second pilot response delay following engine failure may be excessive. GRA

**N86-11199#** McDonnell Automation Co., St. Louis, Mo.
**FLIGHT WORTHINESS OF FIRE RESISTANT HYDRAULIC SYSTEMS: VOLUME 1 Final Report, Jan. 1981 - Dec. 1984**
J. R. JEFFERY, R. B. MERRELL, N. J. PIERCE, M. J. STEVENS, and R. E. YOUNG Dec. 1984 307 p
(Contract F33615-80-C-2074)
(AD-A157618; AFWAL-TR-84-2085-VOL-1) Avail: NTIS HC A14/MF A01 CSCL 13G

This volume reports a study to select a flight worthy hydraulic system in which to test the chlorotrifluoroethylene (CTFE) hydraulic fluid. Aircraft selection, hardware and concept definition, system and weight analysis, and reliability, maintainability and life cycles costs (LCC) studies are reported in volume 1. The F-15 and KC-10A were selected for comparison between the present fluid and system configuraation and CTFE fluid at 8,000 psi plus various energy conservation and water hammer control concepts. The results show the weight penalty of the nonflammable fluid (CTFE) can be overcome by use of 8,000 psi operating pressures. Performance, water hammer transients, fluid pumpability, sealing, null leakage control, and demonstration system effects were investigated during Phases 2 and 3 of this contract. GRA

# 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-10369**
**MAGNETICS AND GUIDANCE SYSTEMS**
D. C. M. MATTHEWS and I. H. BELL (Domain Micro-Systems, Ltd., Stafford, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 23.1-23.7.

The product line of a British manufacturer of magnetic guidance systems for RPV applications is described. Among the products discussed are: magnetic measurement systems; degaussing ranges; fluxgate heading sensors; and magnetic weapons sensors. Consideration is also given to: flux meters; general purpose magnetic instrumentation; and vehicle detection equipment. Black and white photographs of the different devices are provided. I.H.

**A86-10944*#** IBM Federal Systems Div., Owego, N. Y.
**A HELICOPTER TERRAIN FOLLOWING SYSTEM FOR TERMINAL AREA OPERATIONS**
F. G. KILMER, R. L. KILMER (IBM Corp., Federal Systems Div., Owego, NY), H. N. SWENSON (NASA, Ames Research Center, Moffett Field, CA), and A. C. WOODWARD (Texas Instruments, Inc., Dallas) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 8 p.
(AIAA PAPER 85-3092)

This paper discusses the terminal area guidance and terrain following system developed for the USAF HH-60A Night Hawk Search and Rescue Helicopter. A Multi-Mode Radar and three-cue Flight Path Vector Director provide a terrain following capability at all airspeeds, allowing a decelerating approach to a hover over varying terrain to a designated point. Properties of the terrain following design are discussed. Simulation results using the NASA Ames piloted Vertical Motion Simulator are presented. Author

**A86-10945*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SIMULATION EVALUATION OF DISPLAY/FLIR CONCEPTS FOR LOW-ALTITUDE, TERRAIN-FOLLOWING HELICOPTER OPERATIONS**
H. N. SWENSON, C. H. PAULK, JR. (NASA, Ames Research Center, Moffett Field, CA), R. L. KILMER, and F. G. KILMER (IBM Corp., Federal Systems Div., Owego, NY) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. refs
(AIAA PAPER 85-3093)

Trials were run on a six degree of freedom combat helicopter simulator to evaluate head-down displays with integrated FLIR imagery for terrain-following, course-steering, and transition to approach and hover helicopter pilot tasks. Three display formats were tested, providing varying levels of symbology for, e.g., the flight path angle, pitch-attitude data, vertical speed, altitude, etc. The pilots were also furnished flight director guidance, i.e., terrain-following, course steering, airspeed hold, and approach to hover. All the displays permitted the pilots to fly satisfactory mission in the CGI scenarios. The results revealed that the pilots preferred a nonconformal FLIR display superposition. M.S.K.

**A86-11410#**
**TRANSPARENT CONTENTION BUSES CAN IMPROVE ARCHITECTURES**
L. C. KLOS and J. S. HEWELL (General Dynamics Corp., Fort Worth, TX) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 64-74.
(AIAA PAPER 85-5051)

This paper discusses some of the unique architectural aspects of the integration of new systems on aircraft. The paper also describes a data channel approach that meets the diverse and unique requirements of modern avionics. The approach is called 'token passing with transparent contention' and combines a token passing approach for normal operation with a transparent contention approach to handle power-up and bus reconfiguration. The protocol can be used equally well with coaxial cable, fiber optics, or mixed media systems. It provides true distributed control and easily and rapidly overcomes problems due to lost tokens or newly added terminals. Further, it allows a single bus to be dynamically divided into independently operating subnets and supports their smooth reintegration into a single network. Author

**A86-11425#**
**MULTIPROCESSOR APPLICATION IN FLIGHT MANAGEMENT SYSTEMS**
M. K. DEJONGE and T. WILLIAMS (Lear Siegler, Inc., Instrument Div., Grand Rapids, MI) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 172-177. refs
(AIAA PAPER 85-5079)

The Flight Management Computer System (FMCS) for the 737-300 has a three-processor architecture with fixed task allocations divided primarily into the navigation, performance, and input/output functions. The computer architecture uses controlled communication protocol through a global memory accessible to all processors. Advantages of this architecture are in functional separation for testing and validation, and in increased throughput by parallel processing of several system functions. The disadvantage is in the inefficiency of fixed task allocation when a high demand for several tasks allocated to the same processor occur simultaneously, thus limiting the system response time to a single processor's throughput. An alternative multiprocessor architecture for future systems may consider variable task allocation to the processing elements, depending on the availability and capability of each element. A system controller is required to assign tasks as a function of the response priority. In this way, a higher effective throughput is achieved since each processing element is more fully utilized. Issues such as internal bus control, memory access, and priority assignment methods are explored for this type of architecture. Author

**A86-11427#**
**IS THERE A RISC IN THE AVIONIC COMPUTER FUTURE?**
H. SCHMID and T. D. GASKA (General Electric Co., Binghamton, NY) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 185-194. refs
(AIAA PAPER 85-5081)

It has been claimed that Reduced Instruction Set Computers (RISC) offer not only much smaller chips than Complex Instruction Set Computers (CISC) but also more throughput, shorter design time, better support for high level languages, and the ability to emulate other instruction sets. This paper examines these claims and evaluates the possibility of using RISC in real-time avionic control systems that are compatible with MIL-STD-01750. Several methods of translating from 1750 to RISC codes are discussed, and throughput predictions for a VHSIC MIPS are compared with those for the VHSIC 1750 CPUs. B.J.

**A86-11428#**
**WIT - TEST SYSTEM FOR THE MD-80S**
D. R. SWANSON (Douglas Aircraft Co., Long Beach, CA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 195-201.
(AIAA PAPER 85-5082)

The paper examines the system and hardware for the wire integrity test (WIT) system used to verify the integrity of MD-80 aircraft wiring prior to power-up of critical and expensive avionics hardware. Particular consideration is given to the test plan, the aircraft and WIT data bases, the required hardware, the WIT system, types of tests that may be programmed and test results. The success achieved with WIT is noted. B.J.

**A86-11762**
**PRECISE VERTICAL SPEED RECONSTRUCTION BASED ON VERTICAL ACCELERATION AND BAROMETRIC ALTITUDE**
A. REDEKER and P. VOERSMANN (Braunschweig, Technische Universitaet, Brunswick, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, July-Aug. 1985, p. 243-251. refs

The use of two filter algorithms to determine optimum vertical speed estimation is discussed. The equations and diagram explaining the complementary filter and the Luenberger observer are described. The relationship between an estimation of gravitational acceleration and altitude using Newton's gravitational model is provided; vertical acceleration is measured on the Schuler stabilized platform of the inertial navigation system. The hydrostatic equilibrium equation used to measure static pressure is examined. Error models for a vertical accelerometer and a barometric altimeter are presented. The required optimization of the filter parameters is achieved by system simulation; the flight conditions and optimization process are described. The test reveals that the observer is less sensitive than the complementary filter to parametric changes. I.F.

**A86-12572**

### AIRCRAFT STRUCTURE SURVEILLANCE IN-FLIGHT USING ACOUSTIC EMISSION

P. H. HUTTON (Battelle Pacific Northwest Laboratories, Richland, WA) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S138-S141. refs

For a long time, an application of acoustic emission (AE) techniques to the surveillance of critical components in aircraft structures has been considered, taking into account possibilities to detect cracking. The amount of research devoted to such an application, however, has been comparatively small, although there have been some significant development results. The present paper provides a description of a number of cases of such research with the objective to give a perspective of the level of accomplishment. The reported results show the basic feasibility of an in-flight AE monitoring approach. The application of in-flight AE monitoring is being considered in a context of cost effectiveness which results on the basis of the reduction of conventional inspection requirements. G.R.

**A86-12574**

### IN-FLIGHT MONITORING FOR INCIPIENT CRACKS IN AN AERO ENGINE MOUNT - AN APPROACH THROUGH PATTERN RECOGNITION

C. R. L. MURTHY, M. A. MAJEED, S. C. PATHAK, and A. K. RAO (Indian Institute of Science, Bangalore, India) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S147-S150. Research supported by the Aeronautical Research and Development Board.

In-flight monitoring for incipient cracks in critical structural members of an aircraft is a vital need for ensuring safety and operational reliability. A nondestructive, dynamic technique with the capability for in-service monitoring is required. Such a technique can be based on a utilization of acoustic emission (AE). However, the development of a suitable, reliable procedure requires a number of investigations to overcome certain difficulties. Thus, in addition to growing cracks, there are several other pseudosources which give rise to signals which are identical in appearance to acoustic emissions. The present study is concerned with the applicability of principles for source characterization in-flight, taking into account an example involving the testing of a simulated aircraft engine mount in the laboratory as a first step. Attention is given to the design of the mount, the experimental program, a cluster analysis of AE data, software development, and data analysis. G.R.

## 07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-10143#**

### PROPFANS GEAR UP

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1985, p. 22, 24.

The use of a gearbox or a direct-drive engine to power the propfan is examined. The advantages of a gearbox which allows for maximum efficiency are discussed. The smaller direct-drive engine requires 9 percent more hp, weighs 3 percent more, and is 3-5 percent less fuel efficient. The one major advantage of the direct-drive engine is that the elimination of the complex gearbox will permit easier maintenance. The mean time between unscheduled removal of the gearbox for military and commercial aircraft and the types of problems encountered are explained. The material improvements and advanced design techniques, which will reduce all nonmaintenance removal of gearboxes, are described. The use of counter-rotating blades, tapered roller bearing, multispool engine cores, and a hub-mounted electronic pitch change controller to simplify the gearbox is examined. The specific aircraft configuration and its use strongly influence the choice between a geared or gearless propfan. I.F.

**A86-10360**

### VERSATILE, LOW COST TURBOJET PROPULSION FOR UNMANNED VEHICLES

D. E. BARBEAU (Teledyne CAE, Toledo, OH) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 12.1-12.11.

The advantages of a 'family' approach to the design of turbojet engines for unmanned vehicles are discussed. Attention is given to the family of engine designs based on the J402-CA-400 engine of the Harpoon anti-ship missile which serves as the basis for today's low cost propulsion systems in ALCMs, SLCMs, targets, and decoys. The salient features of the J402-CA-400 engine are described, and examples of tailoring to the design requirements of other unmanned vehicles are presented. Among the specific systems considered are: the J402-CA-700 engine for the MQM-107 target drone; the J402-CA-401 engine of the Medium Range Air-to-Surface Missile (MRASM); and the 374-8 engine of the BQM-PI target drone of the U.S. Navy. Some cost factors associated with tailored engine designs are also discussed, including acquisition costs; development costs; and production costs. I.H.

**A86-10361**

### PRESENT AND FUTURE TRENDS IN TURBOJETS AND TURBOFANS FOR R.P.V'S

R. W. CROSS and C. GREGORY (Ames Industrial, Ltd., Fareham, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 13.1-13.12.

Future market trends and design concepts for low-cost turbojet and turbofan engines for RPV applications are discussed. Emphasis is given to the development of gas turbines for missiles, decoys, and target drones. Some of the performance requirements of next generation turbo engines are discussed, including turbofan engines for LRSOMs, small engines for low-profile surveillance RPVs; and supersonic engines for target drones. The product line of a British turboengine manufacturer is described and line drawings of the different engine designs are provided. I.H.

**A86-10362**

### THE STATUS OF A LOW COST GAS TURBINE PROGRAMME

A. J. PURCHASE (Normalair-Garrett, Ltd., Yeovil, England), D. W. ARTT, and N. F. ADAMS (Belfast, Queen's University, Northern Ireland) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 14.1-14.8.

British efforts to develop a low-cost turbine engines unmanned vehicles are described. Attention is given to the engineering program associated with the design of a turbocharger-based engine having 600 N of static thrust. The turbocharger core of the engine was based on existing turbocharger designs. The vaneless diffuser was replaced by an island diffuser and a plenum which also housed the airstart jets and the combustor. The combustor was a conventional reverse flow single can unit made of stainless steel. An electronically controlled fuel system was used to supply oil to the spill burner, with fuel flow controlled by a motor actuated valve in the spill control line. Results of 20 hours of continuous testing of the engine at speeds up to 75000 rpm are preserved. A photograph of the engine on its test-bed is provided. I.H.

**A86-10477#**

**THE EFFECT OF ACOUSTICALLY LINED WALLS ON CASCADE FLUTTER**

S. KAJI (Tokyo, University, Japan) and T. WATANABE JSME, Bulletin (ISSN 0021-3764), vol. 28, July 1985, p. 1359-1366. refs

A linear three-dimensional cascade is modelled using a semiactuator disk. The model takes the effects of both the steady flow turning and the total pressure loss across the cascade into account. The flow field disturbed by the bending oscillation of blades is divided into three regions, the upstream, inside, and downstream of the cascade. In each flow region, the governing equations are solved separately to satisfy the boundary conditions at both tip and hub walls. The regions are then connected to each other to meet the boundary conditions on the leading edge plane and the trailing edge plane of the cascade. The aerodynamic forces acting on the blades can be calculated by applying the momentum principle. It is shown that an acoustically lined wall can stabilize as well as destabilize blade oscillation, depending on its acoustic admittance. C.D.

**A86-10500#**

**AIRCRAFT TURBOFANS - NEW ECONOMIC AND ENVIRONMENTAL BENEFITS**

F. R. SAMPL and M. E. SHANK (United Technologies Corp., Pratt and Whitney Engineering Div., East Hartford, CT) Mechanical Engineering (ISSN 0025-6501), vol. 107, Sept. 1985, p. 47-53.

The reduction of fuel consumption has a great economical significance for the operation of aircraft, because fuel costs account for approximately 50 percent of the direct operating expenses in commercial aircraft engines. Much progress with respect to such a reduction has already been made, and modern jets burn 40 percent less fuel than early turbojets. However, the introduction of advanced turbofan and turboprop engines is expected to reduce fuel consumption by another 40 percent. NASA's Engine Component Improvement (ECI) and Energy Efficient Engine (EEE) programs represent two of the most notable programs dedicated to the reduction of fuel consumption. A number of developments leading to decreased fuel consumption are discussed, taking into account controlled diffusion airfoils, advances in aircraft engine technology, mechanics and electronics, and new materials. G.R.

**A86-10927#**

**INTEGRATED FLIGHT/PROPULSION CONTROL - METHODOLOGY, DESIGN, AND EVALUATION**

K. L. SMITH (General Dynamics Corp., Fort Worth, TX), W. B. KERR (United Technologies Corp., Pratt and Whitney Aircraft Div., West Palm Beach, FL), G. L. HARTMANN (Honeywell, Inc., Minneapolis, MN), and C. SKIRA (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 24 p. refs

(AIAA PAPER 85-3048)

Details of the activities performed during each of four phases of the U.S.A.F. Design Methods for Integrated Control Systems program which produced a set of integrated flight/propulsion control laws are summarized. Phase I produced the integrated control system design requirements for STOL, terrain following/threat avoidance/obstacle avoidance, air-to-air combat maneuvering, air-to-surface combat maneuvering, and supersonic cruise. Phase II work yielded a nonlinear simulation model for steady-state and dynamic characteristics of the aircraft, inlet, engine and nozzle, using a modified F-16XL as the testbed. The design and development of the control logic for each mission segment were accomplished in Phase IV, with the logic being evaluated with the Phase III simulation model. M.S.K.

**A86-10941*#** General Dynamics Corp., Fort Worth, Tex.

**STUDY OF TURBINE BYPASS REMOTE AUGMENTOR LIFT SYSTEM FOR V/STOL AIRCRAFT**

A. E. SHERIDAN (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 14 p. NASA-sponsored research. refs

(AIAA PAPER 85-3086)

The airframe design and engine/aircraft integration were emphasized in a NASA comparative study of turbofan and turbine bypass engine (TBE) with remote augmentor lift systems (RALS) for supersonic V/STOL aircraft. Functional features of the TBE are reviewed, noting the enhanced cycle efficiency and reduced afterbody drag compared to the turbojets. The present studies examied performance levels for aircraft with fleet defense and secondary anti-surface warfare roles, carrying AMRAAM and AIM missiles. TBE engine cycles were configured for hover and up-and-away flight from deck launch, and all tests were done from a conceptual design viewpoint. The results indicate that the TBE-RALS is superior to turbofan-RALS aircraft in both gross take-off weight and life cycle cost. M.S.K.

**A86-10969*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**NET THRUST CALCULATION SENSITIVITY OF AN AFTERBURNING TURBOFAN ENGINE TO VARIATIONS IN INPUT PARAMETERS**

D. L. HUGHES, R. J. RAY (NASA, Flight Research Center, Edwards, CA), and J. T. WALTON AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 9 p.

(AIAA PAPER 85-4041)

The calculated value of net thrust of an aircraft powered by a General Electric F404-GE-400 afterburning turbofan engine was evaluated for its sensitivity to various input parameters. The effects of a 1.0-percent change in each input parameter on the calculated value of net thrust with two calculation methods are compared. This paper presents the results of these comparisons and also gives the estimated accuracy of the overall net thrust calculation as determined from the influence coefficients and estimated parameter measurement accuracies. Author

**A86-10971#**

**DESIGN AND DEVELOPMENT OF A POWER TAKEOFF (PTO) SHAFT FOR THE X-29 FORWARD SWEPT WING (FSW) DEMONSTRATOR AIRCRAFT**

D. J. GARGIULO (Grumman Aerospace Corp., Bethpage, NY) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 9 p.

(AIAA PAPER 85-4045A)

The X-29 Forward Swept Wing (FSW) aircraft required a power takeoff (PTO) shaft to transmit power from the starter to the engine during engine starting and to transmit power from the engine to the remote gearbox during ground and flight operations for aircraft accessories. Shaft design requirements of high speed and great length could not be met with off-the-shelf designs. Meeting adequate critical speed margin posed a significant design problem. Various shaft concepts were studied. The final selection was a graphite epoxy center shaft utilizing metal flexible end assemblies. Extensive testing at unit, subsystem, and system levels proved the adequacy of the design. Author

**A86-11601**

**INTERNATIONAL SYMPOSIUM ON AIR BREATHING ENGINES, 7TH, BEIJING, PEOPLE'S REPUBLIC OF CHINA, SEPTEMBER 2-6, 1985, PROCEEDINGS**

Symposium sponsored by the Chinese Society of Engineering Thermophysics and International Society for Air Breathing Engines. New York, AIAA, 1985, 826 p. For individual items see A86-11602 to A86-11698.

The symposium presents general topics on nozzle and external flows; gas turbine combustor developments; inlets; mechanical aspects; ramjets; controls, diagnostics, and instrumentation;

turbomachinery; combustion stability and modeling; and propulsin systems and test facilities. Other topics include inviscid flow in turbomachinery, operations and monitoring, fuel injection, viscous effects in turbomachinery, unsteady effects in turbomachinery, and combustor performance correlations. Papers are presented on aero gas turbine engines for commercial application, combustion research for gas turbine engines, numerical simulation of self-excited oscillations in a ramjet inlet-diffuser flow, some recent advances in the instrumentation of airbreathing engines, and numerical modeling of afterburner combustion. In addition, consideration is given to procedures for trending aircraft gas turbine engine performance, simultaneous measurement of velocities and particle sizes for injection systems and ramjet combustors, and energy losses of equilibrium three-dimensional boundary layer. I.S.

**A86-11603#**

**THE ROLE OF COMPUTATIONAL TECHNIC IN THE DEVELOPMENT OF HIGH PERFORMANCE AIRBREATHING ENGINES**

J. ROSSIGNOL (SNECMA, Paris, France) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 25-32.

The effect of advanced computational techniques on the development and design of aircraft engines is reviewed with reference to specific examples. In particular, attention is given to the computation of airfoils and of subsonic and transonic flow around airfoils and coupling with the boundary layer; analysis of secondary aerodynamic phenomena; computation of off-design performance and analytical assessment of the compressor map; and compressor stability analysis. The discussion also covers the application of finite element methods and three-dimensional models to mechanical design; combustion modeling; manufacturing process improvement and computerization of the links between design engineering and manufacturing engineering. V.L.

**A86-11604#**

**AERO GAS TURBINE ENGINES FOR COMMERCIAL APPLICATION**

A. G. NEWTON (Rolls-Royce, Ltd., Derby, England) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 33-41.

The progress made in improving the standard of gas turbine engines for commercial applications is briefly reviewed. It is then shown that further gains are possible with the tools that are currently available. Some of these gains could come from the direct applications of available technology to the components of the current configuration of engines or they may be associated with different configurations. Either new versions of the turbo fan engine or even the propeller may come back into use if some significant problems are resolved. These problems include the development of a high-power gearbox, suppression of noise and vibration in the cabin, the development of an advanced propeller, and the development of a suitable gas generator. The economic aspects of such developments are also examined. V.L.

**A86-11608#**

**COMBUSTION ENGINEERING AND RESEARCH FOR GAS TURBINES**

W. W. WAGNER (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) and S. N. B. MURTHY (Purdue University, West Lafayette, IN) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 87-91. refs

The continuing and emerging engineering concerns in gas turbine combustors and several research needs arising from them are reviewed. In particular, improvements are required in compactness, loading, injector performance, linear temperature distribution, uniformity of product composition and temperature both along the chamber and at the exit plane, and manufacture and life. The research that can be expected to bring about such improvements is discussed under the following headings: air supply, design and scales, fuel effects, heat transfer and durability, and control of combustor and engine performance. V.L.

**A86-11609*#** Army Propulsion Lab., Cleveland, Ohio.

**COMBUSTION RESEARCH FOR GAS TURBINE ENGINES**

E. J. MULARZ (U.S. Army, Propulsion Laboratory, Cleveland, OH) and R. W. CLAUS (NASA, Lewis Research Center, Cleveland, OH) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 92-100. Army-supported research. Previously announced in STAR as N85-21164. refs

Research on combustion is being conducted at Lewis Research Center to provide improved analytical models of the complex flow and chemical reaction processes which occur in the combustor of gas turbine engines and other aeropropulsion systems. The objective of the research is to obtain a better understanding of the various physical processes that occur in the gas turbine combustor in order to develop models and numerical codes which can accurately describe these processes. Activities include in-house research projects, university grants, and industry contracts and are classified under the subject areas of advanced numerics, fuel sprays, fluid mixing, and radiation-chemistry. Results are high-lighted from several projects. Author

**A86-11610#**

**DEVELOPMENT OF NEW COMBUSTOR TECHNOLOGIES AT SNECMA**

G. B. LABOURE (SNECMA, Villaroche, France) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 101-108. refs

Major steps of the evolution in the design of the aircraft engine combustors are presented, with discussion of the available design techniques and their advantages, drawbacks and limitations. In particular, the evolution of technology and possible future design trends concerning the combustor injection system, efficiency/pollution performance, reduction in size, cooling technology, and the control and optimizing of the mechanical systems are discussed. The design principles of various combustor features are illustrated graphically. I.S.

**A86-11618#**

**DETERMINATION OF HIGH CYCLE FATIGUE LIFE OF AXIAL COMPRESSOR BLADES OF TURBOJET ENGINES FITTED IN MILITARY AIRCRAFT**

M. L. SIDANA, R. V. NARAYANA MURTHY, and K. SRINIVASA (Defence Research and Development Organization, Directorate of Aeronautics, Bangalore, India) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 173-177.

Results are presented of a study on fatigue life usage rates at various intervals of service hours of the rotor blades in a seven-stage axial compressor that was used in three types of aircraft (fighter, interceptor, and trainer). The rotor blades, made of aluminum alloy RR 58, were tested by means of an electromagnetic exciter linked to a blade-holding block. It was found in the initial studies that from the point of view of the high cycle fatigue (HCF) the second and the third stage rotor blades are the critical ones. The HCF life was highly dependent upon the initial fatigue strength and was a function of vibration environment in terms of the 'af' level in the particular engine installation. The 'af' level in turn depends on the pressure/velocity distortion factors at the engine intake face. I.S

**A86-11623#**

**DIAGNOSIS AND CURE FOR A FATIGUE PROBLEM IN THE TURBINE ROTOR OF A SMALL TURBO-ENGINE**

A. J. VAN WYK and G. V. HOBSON (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 207-211.

Computed and measured blade vibration characteristics of a turbine wheel are discussed in conjunction with engine speed starting characteristics of an integrally cast impulse turbine that failed during its first test. All the turbine blades of the gas generator broke off at their roots causing extensive damage to the exhaust/diffusor housing. The blade vibration and the impulse starter system characteristics were analysed and related to the failure, and the corrective actions recommended. These include static measurement of all modes and their frequencies, with a stress on the usefulness of nonintrusive techniques like laser holography, keeping the historical records of all parameters in a suitable format for a quick backtracking, and a full aeroelastic investigation of turbine blades in simulated rig tests or, ultimately, under real operating conditions. I.S.

**A86-11624#**

**RAMJET RESEARCH IN FRANCE - REALITIES AND PERSPECTIVES**

R. MARGUET and PH. CAZIN (ONERA, Chatillon-sous-Bagneux, France) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 215-224. refs
(ONERA, TP NO. 1985-108)

Thirty years of ramjet research in France are presented, which can be divided into three historical periods: tests on conventional configurations, with the front air intakes and jettisoned boosters (1955-1965), theoretical and experimental research on the hypersonic ramjet for flights at over Mach 6 (1965-1972), and, since 1972, return to moderate supersonic speed ramjets with new designs, more competitive and compatible with operational requirements. Various architectural ramjet configurations, ramjet combustors with the integral booster, compact engine using liquid fuels with high volumetric energy and with solid fuel, and ramrockets with solid fuel containing oxidizer are discussed together with test methods and facilities. Future trends in the ramjet research and development are outlined, stressing the orientation towards military applications. I.S.

**A86-11641#**

**NUMERICAL MODELING OF AFTERBURNER COMBUSTION**

X. ZHANG (Shenyang Aeroengine Research Institute, People's Republic of China) and H.-H. CHIU (Illinois, University, Chicago) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 359-369. refs

A numerical method and a computer code for modeling the afterburner and gas phase combustion processes in turbofan or turbojet afterburners were developed on the basis of the Navier-Stokes equation and a finite difference method. The computer code was shown to be effective and versatile. The numerical analysis revealed that the recirculation zone in the combusting flow is much shorter than in the noncombusting afterburner flow. The multiphase combustion efficiency depends on the principal spray combustion processes. All phenomena reflected by the numerical results coincided with some known experimental data. I.S.

**A86-11646#**

**REAL-TIME ENGINE TESTING IN THE AEROPROPULSION SYSTEMS TEST FACILITY**

N. W. HAARS and J. G. MITCHELL (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 401-407.

The design and development of the Aeropropulsion Systems Test Facility (ASTF) is discussed. The real-time-test (RTT) capability provided by the facility is explained. The advantages and disadvantages of steady-state testing procedures are described and compared with RTT capabilities. The improved testing provided by the control and data systems of the ASTF are discussed. Inlet/engine testing, maneuver transient simulation, and the testing of engine power transients, which are new procedures provided by the ASTF, are explained. The trends in aviation that were studied during the planning of ASTF and the development schedule for the facility are examined. The low cost, time saving testing possible with the RTT at ASTF is explained. I.F.

**A86-11648#**

**A STUDY ON PERFORMANCES OF VARIABLE GEOMETRY TURBOFAN ENGINES UTILIZING AN APPROXIMATED ANALYTICAL METHOD**

C. SANCHEZ TARIFA (Madrid, Universidad Politecnica, Spain) and M. A. LOPEZ AGUILAR (Iberia Lineas Aereas de Espana, Madrid, Spain) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 413-417.

The influence of varying exhaust nozzle areas and specific work of the fan on the fuel consumption of turbofan engines is examined. The analytical expressions used in the approximation method to calculate the performance of both compressors and fan are provided. The actual and calculated data on engine performance are compared and show good correlation. The test parameters are described. The results obtained for specific fuel consumption at take-off and cruise conditions are graphically explained; the data reveals that an increase of exhaust areas will reduce fuel consumption. The data obtained from varying fan flows are discussed. I.F.

**A86-11649#**

**DESIGN CHARACTERISTICS OF A NEW GENERATION TURBOSHAFT ENGINE**

K. TRAPPMANN (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 418-425. refs

Design considerations for a helicopter turboshaft engine are discussed. The functional and economic requirements for engine designs are explained. A diagram of a 900 kW turboshaft engine for a twin engine helicopter and the advantages of its axial/radial compressor and combustion chamber are described. The evaluation of the engine design and the improvements required are examined. A new engine design, which was developed because of major advances in compressor and turbine aerodynamics, is described. A comparison of the combustion chamber, and compressor turbine and cooling system of the two engine designs is provided; the improvements required in the new design are explained. I.F.

**A86-11650#**

**THE AERODYNAMIC AND THERMODYNAMIC DESIGN OF A SMALL TURBOJET**

C. MASSARO, S. COLANTUONI, P. DI MARTINO, G. LIOTTI (Alfa Romeo Avio S.p.A., Naples, Italy), and G. TORELLA (Italian Air Force Academy, Italy) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 426-432. refs

This paper deals with the activities carried out during the AR/TJ140 small turbojet design and development. The theoretical, experimental and numerical methods that have been set up are based on the experiences made during the design of ESM 600 turboshaft and AR318 turboprop engines. The problems connected with the different phases of the project are considered here. The paper deals with design choice, compressor and turbine aerodynamic problems and with performance predictions. For each argument the problems that have been met and the selected solutions are shown. Author

**A86-11661#**

**ENGINE PERFORMANCE MONITORING IN HELICOPTERS**

D. E. GLENNY (Aeronautical Research Laboratories, Melbourne, Australia) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 513-519.

Methods to monitor the performance of helicopter engines are described. The first method, manual In-Flight Monitoring (IFM) relies solely on data manually recorded by the pilot and interpretations by maintenance personnel. The second method, a computerized engine performance monitoring system, consists of a set of automatically recorded data and a gas flow analysis routine to diagnose performance trends in flight. The data screening requirements of the automatic system are described, and some preliminary results of 300 hours of tests on a T53-Li3 helicopter engine are presented. It is shown that, except for obvious instrument malfunctions, torque drop-outs, and speed fluctuations, consistent trends in engine performance parameters can be accurately predicted using the automatic system. Trend plots of the torque of the T53-L13 engine are given in a table. I.H.

**A86-11662#**

**PROCEDURES FOR TRENDING AIRCRAFT GAS TURBINE ENGINE PERFORMANCE**

D. A. FRITH and P. C. FRITH (Aeronautical Research Laboratories, Melbourne, Australia) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 520-527. refs

A procedure is proposed to extract information from aircraft engine performance measurements. The condition parameters used in the procedure include: blade erosion, seal wear, and deterioration in the gas path regions of the engine. Some sources of noise error in performance measurements are discussed, and the use of an uncertainty interval to identify hidden biases in predicted trends is described. A flowchart for the procedure is provided. I.H.

**A86-11663#**

**JT9D ENGINE/MODULE PERFORMANCE DETERIORATION RESULTS FROM BACK TO BACK TESTING**

O. SASAHARA (Japan Air Lines, Co., Ltd., Tokyo, Japan) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 528-535.

The results of back-to-back performance testing of JT9D-7A gas turbine commercial aircraft engines are presented. Specific performance losses were computed for individual engine modules using a Module Analysis Program (MAP). The performance deterioration data for individual gas-path modules are derived and some damage mechanisms are examined. A list of the dependent and independent variables in the performance data is obtained on the basis of the computer analysis. A detailed line drawing of the JT9D engine is provided. I.H.

**A86-11664#**

**CERTAIN ALGORITHMS RELATED TO 'ENGINE CONDITION MONITORING' SYSTEMS**

TH. TH. PANIDIS and D. D. PAPAILIOU (Patras, University, Greece) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 536-539.

The algorithms used to predict gas turbine engine performance in conjunction with the Gas Path Analysis (GPA) technique are described. The function of the algorithms is to relate engine parameter derivations from their normal values to corresponding cases of engine failure. Deviating parameters are compared to sets of parameter matrices which describe the possible sources of engine defect using a Set of Deviating Parameters Algorithm (SPDA). Existing faults are identified using Condition Vector Algorithms (CVAs) to provide quantitative information regarding the parameter deviations. An Engine Monitoring (ECM) system integrating the two algorithms is described and its application to defect analysis in a three-spool turbofan engine is discussed. I.H.

**A86-11665#**

**HOSTILE ATMOSPHERIC ENVIRONMENT EFFECTS ON JET ENGINES**

W. TABAKOFF and A. HAMED (Cincinnati, University, OH) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 540-549. refs
(Contract DAAG29-82-K-0029)

The dynamics of solid particles ingested through a helicopter turbine engine having an inlet particle separator have been investigated, theoretically. The distribution of the unseparated particles and the locations of particle-blade impacts were determined by computing the particle trajectories through the five stage axial compressor. It is shown that the distribution of particle impacts is not uniform between the blade pressure surfaces and the blade section surfaces in the compressors and stators. The patterns of blade erosion due to particle impacts are illustrated in a series of line drawings. I.H.

**A86-11666#**

**INITIAL DISPERSION OF JET ENGINE EXHAUST PLUME**

T. SAWADA (Osaka Prefecture, University, Sakai, Japan) and A. NISHI (Miyazaki University, Kirishima, Japan) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 550-557. refs

Experiments were carried out using a laboratory model in order to study the physical characteristics of a co-axial jet engine exhaust plume near the ground. Estimates are obtained of the velocity, temperature, and chemical composition of the model jet, and the results are compared with field measurements collected at Chitose Airport in Hokkaido, Japan. The combined data are used to predict the deflection of the jet axis due to cross winds and the different buoyancies of the jet flow in the idle mode and during takeoff. I.H.

**A86-11693#**

**A STUDY OF THE FREQUENCY RESPONSE OF A TURBOJET ENGINE TO TURBULENCE-TYPE DYNAMIC DISTORTION**

F. CHEN, W. LI, Z. WANG, M. CONG (Northwestern Polytechnical University, Xian, People's Republic of China), and S. LIU IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 765-771. refs

A study of frequency response of a turbojet engine to turbulence-type dynamic inlet distortion (TTDD) was studied, analyzing the input/output compressor signals by means of a statistical analysis technique for stochastic processes. The TTDD was generated by a plate with 180 deg extent and 50 percent blockage ratio at the engine face. The results indicate that the engine compressor system is most sensitive to the intermediate frequency fluctuations just before the onset of surge. I.S.

**A86-11697#**
**TRANSPORTATION AND IMPINGEMENT/EFFUSION COOLING OF GAS TURBINE COMBUSTION CHAMBERS**
G. E. ANDREWS, A. A. ASERE, C. I. HUSSAIN, and M. L. MKPADI (Leeds, University, England) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 794-803. refs
(Contract SERC-GR/B/67827; SERC-B/00336; SERC-GR/C/59192)

The overall cooling effectiveness of a combined impingement plate (IP)-full coverage discrete hole effusion (E) cooling system for cooling gas turbine chambers was compared to the transpiration (T), or porous wall cooling. The phenomenon of heating the IP by the impingement air was also investigated. At low coolant flow rates, the E cooling could match the film cooling effectiveness of a fully porous wall. The lower overall cooling effectivenesss performance consequently results from inferior internal wall cooling. Although the combination of IP with E led to a major improvement in the overall cooling effectiveness, it remained inferior to the T cooling system. Heating of IP by the reflected impingement jets is maximized at low coolant flow rates and small impingement hole diameter, but is not influenced by the distance between the IP and the air source in the distance range of 3-12 mm. I.S.

**A86-11757**
**DEPOSITS IN AIRCRAFT ENGINES. I - TYPE OF DEPOSITS AND TEST METHODS [ABLAGERUNGEN IN FLUGTRIEBWERKEN. I - ERSCHEINUNGSFORMEN UND TESTMETHODEN]**
K. MAIER (Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) and E. JANTZEN (DFVLR, Institut fuer technische Physik, Stuttgart, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, July-Aug. 1985, p. 211-217. In German. refs

Oil-reaction-product deposit formations in the oil systems of aircraft engines are examined. The location and the types of deposits detected and the factors which influence their formation are explained and diagrams of deposit formations are provided. The characteristics of the deposits, which are used to classify them, are described. The laboratory techniques used to study deposit formations, which include static and dynamic electric stress tests in the liquid phase, droplet phase tests, and oil steam phase tests, are analyzed and examples of specific equipment utilized are presented. The specifications which must be followed when using these techniques are presented and the effect of temperature on deposit formation is discussed. I.F.

**A86-11955**
**AEROJET TECHSYSTEMS DEVELOPS HYPERSONIC AIRCRAFT ENGINE**
J. T. MERRIFIELD Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Oct. 14, 1985, p. 57, 59, 60, 65.

An American aerospace company is developing the Airturboramjet engine for hypersonic transatmospheric vehicles. It is believed that the engine could be ready for a flight demonstration within four years. The Airturboramjet, designed to operate like a turbojet at subsonic speeds and like a fan-boosted ramjet at supersonic and hypersonic speeds, could provide the necessary propulsion for hypersonic transport which has been proposed. A three-year project is to prove the concept of a hydrogen-fueled Airturboramjet. The project includes design, fabrication, and testing of a subscale engine at simulated Mach 5 and 100,000-ft altitude conditions. G.R.

**A86-12010**
**TAY FOR TWO**
J. MOXON Flight International (ISSN 0015-3710), vol. 128, Sept. 28, 1985, p. 21-26.

The development of a turbofan, Tay, is described. The Spey Mk 555 was used as the basis for the Tay engine. The use of the engine in two aircraft and the need for the engine to be produced at reasonable cost are explained. The reduction of the high jet velocity by raising the bypass ratio is discussed. The development of a low-pressure spool, and an intermediate-pressure compressor are described; the functions of the intermediate-pressure compressor are discussed. A new combustor, a 12-lobe exhaust mixer, an acoustic liner to reduce noise, and an all-composite bypass duct used in the design of the turbofan are explained. A diagram of the Tay engine is provided. I.F.

**A86-12365**
**PROPELLER POWER**
M. HIRST Air International (ISSN 0306-5634), vol. 29, Oct. 1985, p. 190-194.

The evolution of the propeller due to advances in turboprop technology is discussed. The development of variable-pitch propellers and examples of aircraft utilizing them are described. The need to reduce the rotation speed between the gas turbine and the propeller drive shaft, in the variable pitch propeller, led to a turboprop engine; the characteristics of this engine type are explained. The problems encountered with gearboxes and the use of turboshaft engines are examined. A comparison of turboprop and turbofan engines is presented. The development and testing of a propfan engine, which is a turbofan engine that can achieve a higher turbine operating temperature, are described. I.F.

**A86-12531**
**THE EFFECT OF THE INITIAL TEMPERATURE NONUNIFORMITY AND EXCESS AIR RATIO OF THE AFTERBURNER OF A GAS-TURBINE ENGINE ON THE SPECIFIC PULSE OF THE NOZZLE [VLIIANIE NERAVNOMERNOSTI NACHAL'NOI TEMPERATURY I KOEFFITSIENTA IZBYTKA VOZDUKHA V FORSAZHNOI KAMERE GTD NA UDEL'NYI IMPUL'S SOPLA]**
V. N. GRUZDEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 21-24. In Russian. refs

The specific pulse reduction factor of a nozzle is calculated for the maximum temperature nonuniformity at the nozzle inlet that is possible for the afterburner of a bypass engine. It is shown that the observed discrepancy between the effective and 'chemical' heat release ratios is largely determined by the effect of the nonuniformity of the temperature field on the specific pulse of the nozzle. V.L.

**A86-12532**
**A STUDY OF THE SWIRLING OF A LIQUID BY POROUS ROTORS [ISSLEDOVANIE ZAKRUTKI ZHIDKOSTI PORISTYMI KOLESAMI]**
IU. V. DRONOV, A. A. PANCHENKO, and V. F. PRISNIAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 25-28. In Russian.

The swirling of a liquid by the porous rotors of centrifugal pumps is investigated experimentally as a function of the inlet diameter and of the porosity factor. An empirical expression for estimating the swirling of a liquid at the outlet side of the rotor is obtained. Experimental results are presented for water. V.L.

**A86-12541**
**A METHOD FOR DESIGNING A SURGE PROTECTION DEVICE FOR GAS TURBINE ENGINES [OB ODNOM SPOSOBE POSTROENIIA USTROISTVA ZASHCHITY GTD OT POMPAZHA]**
M. M. SHAKIRIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 64-68. In Russian. refs

The possibility of recognizing the unstable operation of an aircraft engine using the Van der Pol equation is investigated. The conditions defining the gasdynamic stability region of a gas-turbine engine are then obtained and implemented in an automatic surge protection system. The general design and the principle of operation of the system are described. V.L.

**A86-12544**

**A STUDY OF THE EFFECT OF ROTOR BLADING PARAMETERS ON THE REGION OF ACCEPTABLE DESIGN SOLUTIONS FOR THE ATTACHMENT OF AIRCRAFT COMPRESSOR BLADES [ISSLEDOVANIE VLIIANIIA PARAMETROV PROTOCHNOI CHASTI KOLESA NA OBLAST' DOPUSTIMYKH PROEKTNYKH RESHENII PO UZLAM KREPLENIIA LOPATOK AVIATSIONNYKH KOMPRESSOROV]**

B. M. ARONOV and V. A. KAMYNIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 75-77. In Russian.

In order to assess the possibility of using particular types of blade-root fastenings at an early stage of design, the knowledge of the effect of rotor blading parameters on the region of acceptable design solutions for the fastenings is required. Here, the relationship between the parameters of the rotor blading and the region of acceptable design solutions is analyzed using a full factorial experimental design. Results are presented for blades and a rotor made of VT-9 alloy. V.L.

**A86-12546**

**DETERMINATION OF THE THRUST OF A BYPASS ENGINE UNDER OPERATING CONDITIONS [OPREDELENIE TIAGI TRDD V USLOVIIAKH EKSPLUATATSII]**

A. D. KOZITSKII and V. T. SHEPEL Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 79-81. In Russian.

A method for determining the thrust of a bypass engine is proposed which uses as the initial data the rotor rpm and fuel consumption, i.e., parameters that can be easily measured during the operation of the engine, rather than the full gas pressure behind the turbine. The method is simple to implement and sufficiently accurate. For a plus or minus 2-sigma variance, the maximum relative error of thrust determinations is plus or minus 1.7 percent; with a correction for the individual compressor output, the maximum relative error is reduced to plus or minus 1.2 percent. V.L.

**A86-12548**

**A STUDY OF A TURBINE STAGE WITH A TWISTED VANED DIFFUSER [ISSLEDOVANIE TURBINNOI STUPENI S ZAKRUCHENNYM LOPATOCHNYM DIFFUZOROM]**

S. M. LANGOVOI and IU. I. MITIUSHKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 83-85. In Russian. refs

Tests have been carried out on a turbine stage with cylindrical blading to determine the effect of a twisted vaned diffuser on the turbine performance. It is shown that a diffuser with twisted vanes reduces the maximum efficiency of the turbine stage by about 0.6 percent, while significantly decreasing the optimum value of the velocity characteristic (from 0.625 to 0.54). It is also shown that the use of a twisted vaned diffuser has little effect on the thrust characteristics and improves the economy of the turbine stage by approximately 1 percent in the velocity characteristic range 0.43-0.53. V.L.

**A86-12549**

**UNSTEADY OPERATION OF THE FUEL NOZZLES OF THE MAIN COMBUSTION CHAMBER OF A GAS-TURBINE ENGINE [O NESTATSIONARNOI RABOTE TOPLIVNYKH FORSUNOK OSNOVNOI KAMERY SGORANIIA GTD]**

E. IU. MARCHUKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 86-88. In Russian. refs

The mechanisms of acoustic wave generation in the centrifugal fuel nozzles of the combustion chamber of a gas-turbine engine are investigated experimentally and found to be of hydrodynamic nature. In particular, the phenomenon of self-oscillatory flow in centrifugal fuel nozzles with nonsubmerged outflow is identified. The unsteady operation of fuel nozzles significantly intensifies mixing processes but, at the same time, can lead to combustion instability in the combustion chamber. The need for further studies of the phenomenon described here is emphasized. V.L.

**A86-12555**

**HIGH-SPEED LASER PHOTORECORDING OF A FUEL NOZZLE JET [LAZERNAIA SKOROSTNAIA FOTOREGISTRATSIIA FAKELA FORSUNKI]**

V. P. SHORIN, O. A. ZHURAVLEV, L. N. MEDINSKAIA, A. G. OSADCHUK, and V. V. TOKAREV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 100-102. In Russian. refs

The existing methods of monitoring the structure of a fuel jet injected into the combustion chamber of a gas-turbine engine are briefly reviewed, and the advantages of high-speed laser photorecording (the laser knife method) are examined. This method makes it possible to visualize the structure of the jet and to determine the velocity distributions of gas flow by injecting monodisperse particles with specified optical properties. Experimental results for a fuel jet injected by a pneumatic nozzle are presented which show that reliable recording of the jet structure is achieved with an energy density in the laser knife of 250 J/sq m, which can be provided by an unamplified ruby laser. V.L.

**A86-12599**

**ASSURING THE RELIABILITY OF AIRCRAFT ENGINES [OBESPECHENIE NADEZHNOSTI AVIATSIONNYKH DVIGATELEI]**

N. D. KUZNETSOV Akademiia Nauk SSSR, Vestnik (ISSN 0002-3442), no. 8, 1985, p. 85-92. In Russian.

The problem of the reliability of aircraft engines is examined with emphasis on the methodology of optimum design. In particular, attention is given to the optimization of the initial factors and principal gasdynamic parameters, mathematical description of physical processes occurring in gas turbines, and the role of computers in optimum design. The discussion also covers special tests for gas-turbine engines, the effect of process variables on the fatigue behavior of turbine blades, surface treatment techniques for hardening gas-turbine components, and new engine diagnostic methods and equipment. V.L.

**N86-11148#** Lockheed-Georgia Co., Marietta. Advanced Concepts Dept.

**A REVIEW OF ADVANCED TURBOPROP TRANSPORT ACTIVITIES**

R. H. LANGE *In* AGARD Aerodyn. and Acoustics of Propellers 16 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

The application of advanced technologies shows the potential for significant improvement in the fuel efficiency and operating costs of future transport aircraft envisioned for operation in the 1990s time period. One advanced turboprop concept originated by Hamilton Standard and NASA is known as the propfan. The concept features a highly loaded, multibladed, variable pitch propeller geared to a high pressure ratio gas turbine engine. The blades have high sweepback and advanced airfoil sections to achieve 80 percent propulsive efficiency at M = 0.80 cruise speed. Aircraft system studies have shown improvements in fuel efficiency of 15 to 20 percent for propfan advanced transport aircraft as compared to equivalent turbofan transports. Beginning with the Lockheed C-130 and Electra turboprop aircraft, an overview of the evolution of propfan aircraft design concepts and system studies is presented. These system studies include possible civil and military transport applications and data on the performance, community and far field noise characteristics and operating costs of propfan aircraft design concepts. NASA Aircraft Energy Efficiency (ACEE) program propfan projects with industry are reviewed with respect to system studies of propfan aircraft and recommended flight development programs. Author

**N86-11149#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

**AERODYNAMIC METHOD USED IN FRANCE FOR ADVANCED FAST PROPELLER STUDY**

J. M. BOUSQUET *In* AGARD Aerodyn. and Acoustics of Propellers 15 p Feb. 1985 refs In FRENCH; ENGLISH summary Original language document previously announced in IAA as A85-15840

Avail: NTIS HC A20/MF A01

Computational techniques and programs currently in use in the design analysis of aircraft propellers are surveyed and illustrated with diagrams and graphs of typical results. Methods examined include lifting line, incompressible lifting surface, three dimensional compressible, and three dimensional Euler; both classical and advanced propeller designs are considered. The Euler analysis of the experimental propeller HT1 being developed for ONERA is explored in detail, evaluating the effects of tip speed ratio, Mach number, number of blades, hub diameter, and a tapered diameter hub shroud. T.K.

**N86-11150#** Centre National de la Recherche Scientifique, Orsay (France).

**DESIGN CONCEPT AND PERFORMANCE PREDICTION TECHNIQUE FOR POTENTIAL FLOWS AROUND ADVANCED PROPELLERS**

T. S. LUU and R. COLLERCANDY *In* AGARD Aerodyn. and Acoustics of Propellers 12 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

The design concept and performance prediction technique for potential flows around advanced propellers is presented. The design of propellers is based on the panel method, applied to the lifting surface theory in which the flow is supposed to be incompressible. A transonic performance prediction technique is developed where the resulting potential equation is solved by a finite difference approximate factorization method in a body fitted grid system. Both two and three dimensional results are presented. Author

**N86-11151#** Aircraft Research Association Ltd., Bedford (England).

**A REVIEW OF ARA RESEARCH INTO PROPELLER AERODYNAMIC PREDICTION METHODS**

A. J. BOCCI and J. I. MORRISON *In* AGARD Aerodyn. and Acoustics of Propellers 19 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

An improved wake method involving a numerical solution to Goldstein's wake flow model was developed and the effects of removing Goldstein's limiting assumptions are illustrated. The representation of ARA-D airfoil data for use with the wake methods is considered, covering the wide range of geometry and flow conditions likely to be encountered on operating blades. The importance of finite blade effects is discussed and a tip relief correction is shown to improve predictions of experimental blade pressures and loadings. A method was developed to calculate the flow induced by a prescribed wake vortex sheet and some of the issues arising in calculating the flow development from the propeller disc downstream are illustrated. A three dimensional method involving solution of the compressible potential flow equation was developed, capable of predicting the blade flow in some detail for general multiblade configurations. Comparisons with experiment are shown for two blade cases. Author

**N86-11152#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

**MODERN PROPELLER PROFILES**

A. M. RODDE, J. J. CUNY (Societe Ratier Figeac, France), and J. J. THIBERT *In* AGARD Aerodyn. and Acoustics of Propellers 12 p Feb. 1985 refs In FRENCH Original language document previously announced in IAA as A85-15841

Avail: NTIS HC A20/MF A01

The design of a family of advanced profile composite aircraft propellers is presented, and the results of wind tunnel tests performed at the ONERA Modane S3 and CEATY S10 facilities are reported. The design specifications are outlined; the definition of profiles with relative thicknesses 4, 7, 12, and 20 percent is explained; and the test results are presented in graphs and diagrams. Significant performance improvements (relative to a NACA 16707 reference profile) are observed, including 43 and 8 percent better lift/drag ratios for cruising and ascent, respectively, 15 percent better Cz max, and equivalent critical Mach number at lower drag. The first planned application is to the Transall C160 two engine turboprop transport aircraft. T.K.

**N86-11153#** National Aerospace Lab., Amsterdam (Netherlands).

**AERODYNAMICS OF WIDE-CHORD PROPELLERS IN NON-AXISYMMETRIC FLOW**

J. B. H. M. SCHULTEN *In* AGARD Aerodyn. and Acoustics of Propellers 10 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

A lifting surface analysis is presented for propellers in nonaxisymmetric flow. In the analysis the Euler equations linearized about a uniform subsonic main flow are solved after separation of variables in cylindrical coordinates. This solution is obtained via an integral equation for the force distribution over the upper and lower surfaces of the blades which replaces the action of the propeller on the surrounding fluid. The boundary condition of vanishing normal velocity is applied at the actual blade surfaces, thus leading to a nonhelicoidal, unsteady lifting surface theory for propellers. Since the integral equation is solved most efficiently per circumferential Fourier component of the inflow distortion field, symmetric inflow is included naturally as the zeroth term of the Fourier series. General blade shapes can be handled as the blades may be swept both axially and azimuthally. There is no inherent limitation to the propeller tip Mach number. Apart from the calculation of the unsteady blade loading, expressions for the velocity and pressure fields are derived, in which the propeller slipstream appears explicitly as part of the complete velocity field in a form perfectly suited for wing interference calculations. Author

**N86-11154#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.

**ON THE AERODYNAMICS OF INSTALLED PROPELLERS**

M. E. ESHELBY *In* AGARD Aerodyn. and Acoustics of Propellers 15 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

When the propeller is installed on the aircraft there will be mutual influence between the airframe and the propeller and its slipstream, two sources of that interference are examined. First, as the aircraft angle of attack changes with forward speed the angle of attack of the propeller also changes giving rise to forces and moments other than thrust and torque. Second, the high energy slipstream may pass over the tailplane and so affect the tail lift force, and in consequence a pitching moment due to power may be produced. These two effects are considered separately and means are suggested to estimate their magnitude and their effect on the handling qualities of the aircraft. Author

**N86-11155#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.

**A UNIFIED APPROACH FOR THE AERODYNAMICS AND ACOUSTICS OF PROPELLERS IN FORWARD MOTION**

A. DAS *In* AGARD Aerodyn. and Acoustics of Propellers 28 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

The aerodynamics and the acoustics of moving bodies or surfaces follow the same basic laws of disturbance propagation and hence can be treated in a unified way. Further advancements of the propeller theories have two objectives: attaining better propulsive efficiency and producing less noise at high forward speeds. A unified aerodynamic and acoustic theory of propeller in forward motion is formulated and analyzed in detail describing the aspect of disturbance propagation from singularities in arbitrary motion, derivation of the spatial and temporal dilatations concerned with the propagation process, generalized exposition of the solution method for aerodynamics and acoustics and an extended sweep technique to determine the inducing effect of moving surfaces. In view of the flow field of a propeller being not completely irrotational the use of pressure potential proves to be more suitable in the numerical methods. The results of the analysis are illustrated by diagrams. Author

**N86-11156*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THEORETICAL ANALYSIS OF LINEARIZED ACOUSTICS AND AERODYNAMICS OF ADVANCED SUPERSONIC PROPELLERS**
F. FARASSAT *In* AGARD Aerodyn. and Acoustics of Propellers 15 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 01A

The derivation of a formula for prediction of the noise of supersonic propellers using time domain analysis is presented. This formula is a solution of the Ffowcs Williams-Hawkings equation and does not have the Doppler singularity of some other formulations. The result presented involves some surface integrals over the blade and line integrals over the leading and trailing edges. The blade geometry, motion and surface pressure are needed for noise calculation. To obtain the blade surface pressure, the observer is moved onto the blade surface and a linear singular integral equation is derived which can be solved numerically. Two examples of acoustic calculations using a computer program are currently under development. Author

**N86-11157#** Lockheed-California Co., Burbank.
**A GENERAL THEORY OF ARBITRARY MOTION AERODYNAMICS USING AN AEROACOUSTIC APPROACH**
L. N. LONG and G. A. WATTS *In* AGARD Aerodyn. and Acoustics of Propellers 12 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

The theoretical aspects of a new unsteady aerodynamics method that uses time domain aeroacoustic integral equations is described. Recent advances in theoretical aeroacoustics permit the development of general unsteady aerodynamics methods. The effects of thickness, compressibility, and arbitrary motions may be calculated for subsonic and supersonic flows. Most linearized unsteady aerodynamics methods today are limited to zero thickness effects and sinusoidal motion. The equations presented will make it possible to develop computer codes for complex three dimensional bodies, including not only complete aircraft configurations, but rotating propellers and helicopter blades as well. Panel methods for steady aerodynamics are widely used in the aircraft industry for such configurations, the present method should permit equally general configurations to be solved in unsteady motion, using a time stepping procedure. Author

**N86-11158*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**SUMMARY OF RECENT NASA PROPELLER RESEARCH**
D. C. MIKKELSON, G. A. MITCHELL, and L. J. BOBER *In* AGARD Aerodyn. and Acoustics of Propellers 24 p Feb. 1985 refs Previously announced as N84-32344
Avail: NTIS HC A20/MF A01 CSCL 01A

Advanced high speed propellers offer large performance improvements for aircraft that cruise in the Mach 0.7 to 0.8 speed regime. At these speeds, studies indicate that there is a 15 to near 40 percent block fuel savings and associated operating cost benefits for advanced turboprops compared to equivalent technology turbofan powered aircraft. Recent wind tunnel results for five eight to ten blade advanced models are compared with analytical predictions. Test results show that blade sweep was important in achieving net efficiencies near 80 percent at Mach 0.8 and reducing nearfield cruise noise about 6 dB. Lifting line and lifting surface aerodynamic analysis codes are under development and some results are compared with propeller force and probe data. Also, analytical predictions are compared with some initial laser velocimeter measurements of the flow field velocities of an eight bladed 45 swept propeller. Experimental aeroelastic results indicate that cascade effects and blade sweep strongly affect propeller aeroelastic characteristics. Comparisons of propeller nearfield noise data with linear acoustic theory indicate that the theory adequately predicts nearfield noise for subsonic tip speeds, but overpredicts the noise for supersonic tip speeds. B.W.

**N86-11159#** Societe Nationale Industrielle Aerospatiale, Marignane (France).
**DYNAMIC BEHAVIOR OF A PROPFAN**
J. M. BESSON and D. PETOT (ONERA, Paris) *In* AGARD Aerodyn. and Acoustics of Propellers 15 p Feb. 1985 refs In FRENCH Original language document previously announced in IAA as A85-15842
Avail: NTIS HC A20/MF A01

The dynamic behavior of a 1 m diameter 12 blade propfan model is investigated analytically and experimentally. Both the propfan and its individual blades are analyzed using two versions of a simplified beam model and the finite element codes ASTRONEFF and SAMCEF, considering blades of Dural alloy, CFRF, and foam filled CFRP. The modeling techniques are illustrated, and results are presented in graphs and tables. The single blade findings are compared with the results of wind tunnel tests performed at the ONERA Mondane S1 facility, and the errors of the models are found to be of the order 10 percent. The ASTRONEFF procedure is shown to be best adapted to the foam filled ribbed CFRP blade to be used in the actual propfan model. Preliminary computations of the aerodynamics and static deformation of the propfan are also presented. T.K.

**N86-11160#** De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
**PERFORMANCE EVALUATION OF FULL SCALE PROPELLERS BY WIND TUNNEL TEST**
D. J. BARBER *In* AGARD Aerodyn. and Acoustics of Propellers 12 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

A large propeller test facility was developed for the nine meter wind tunnel. The facility is described along with the propeller test rig features and associated drive system. Propeller performance measurement philosophy, test procedures and calibrations are discussed. In cooperation with Dowty Rotol Ltd. and Hartzell Inc., two currently available propeller designs were tested. The two 8.5 foot diameter propeller suitable for a DHC Twin Otter size of aircraft provided an evaluation of alternative airfoil applications: the ARA-D series and NACA 16 series. Results have demonstrated propeller efficiencies close to manufacturers estimates for clean well finished blades. Forward and reverse thrust testing results are discussed with respect to aircraft application. Prediction methods tend to over estimate efficiencies due to hardware features encompassing blade finish, blade root/spinner juncture, spinner openings, erosion protection and deicer equipment. Typical results illustrating the influence on propeller performance of such features is given. Author

**N86-11161#** Institut de Mecanique des Fluides de Marseille (France).
**STUDY OF THE 3D WAKE OF AN AERIAL PROPELLER [ETUDE DU SILLAGE 3D D'UNE HELICE AERIENNE]**
D. FAVIER and C. MARESCA *In* AGARD Aerodyn. and Acoustics of Propellers 22 p Feb. 1985 refs In FRENCH
Avail: NTIS HC A20/MF A01

An analysis of the near and far wake of a four blade aerial propeller, operated under various working parameters and following various adjustments, was carried out with hot wire anemometry. Empirical laws were synthesized which provide the axial translation velocity of the tip vortices, the rate of wake radial contraction, in such a way that the stability limit of the vortex system is established as a function of azimuth rotation and as an extended range of the working parameters active in the range from null to maximum thrust. For a given functional regime, the determination of the three dimensional induced velocity field is effective in different sections downstream of the wake and conducted in a detailed characterization of the geometry and associated vortex intensity, in the azimuth function and the axial distance to the downstream of the plane of rotation. E.A.K.

**N86-11162#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
**INVESTIGATIONS OF MODERN GENERAL AVIATION PROPELLERS**
H. ZIMMER, R. HOFFMANN (Hoffmann-Propellers, Rosenheim, West Germany), and K. H. HORSTMANN (DFVLR, Brunswick) *In* AGARD Aerodyn. and Acoustics of Propellers 14 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

After a period of stagnation in the years following WW2 an accelerated movement towards propeller propulsion has taken place in recent years. Because of its inherent propulsive advantages the propeller propulsion has a considerable development potential. Initial analyses of the state of the art of propeller technology in the General Aviation field by means of flight and wind tunnel tests as well as by aerodynamic and acoustic calculations have shown possibilities for improvement, mainly in the lower and medium speed range. Improved propellers were designed and analyzed theoretically and experimentally. Newly designed supercritical airfoils with high lift to drag ratios at high lift were used. To find the optimum blade shapes associated with minimum supervelocities, also several tip shapes were analyzed. After wind tunnel tests the best of the propeller designs was selected for full scale flight test. A set of experimental propellers for the Do 228 Experimental aircraft was developed, constructed and tested. Improvements were achieved in the whole flight regime. The experience of this propeller development program was used to design a high performance high speed General Aviation propeller for M = 0.6 flight. Author

**N86-11163#** Dowty Rotol Ltd., Gloucester (England).
**AERODYNAMIC AND STRUCTURAL ASPECTS OF PROPELLER AND DRIVE FOR A 1/5 SCALE WIND TUNNEL PROGRAMME**
R. M. BASS, B. MUNNIKSMA (National Aerospace Lab., Amsterdam), and J. VANHENGST (Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost) *In* AGARD Aerodyn. and Acoustics of Propellers 18 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

The paper describes the development of a model propeller and its calibration in association with an axisymmetric nacelle in the National Aerospace Laboratory low speed tunnel in Amsterdam before testing on a complete 1/5 scale model of the Fokker in the DNW (German-Dutch wind tunnel). The calibration so obtained, allowed the required operating propeller conditions to be set up on the complete F50 model. The influence of Reynolds number on correction for scale effects, between experimental model results and full scale prediction. A previously unsuspected and unavoidable vibration originating in the reduction gear train of the drive unit gave rise to high propeller blade stresses, ultimately leading to a blade failure. In order to continue running with minimum delay, new propeller blades with high internal damping were manufactured from composite materials, and the program was successfully concluded. Author

**N86-11164#** De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
**SOME CONSIDERATIONS IN PROPELLER AND AIRFRAME INTEGRATION**
B. EGGLESTON *In* AGARD Aerodyn. and Acoustics of Propellers 11 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

The paper review elected items of R and D limited in support of propeller driven transport aircraft. The topics include the design of new propeller airfoils, two dimensional tests of selected airfoils, and estimates are presented of the resulting benefits in propeller performance. The application of numerical optimization to the aerodynamic design of propeller is also reviewed. Some results from wind tunnel tests of airframe/propeller installations are presented showing the benefits of alternative nacelle shape and the merits of high versus low wing locations on a transport aircraft. Author

**N86-11165#** Avions Marcel Dassault, Saint-Cloud (France). Div. des Etudes Avancees.
**PROBLEMS OF THE INTEGRATION OF PROPELLERS IN AIRFRAMES, ESPECIALLY FOR HIGH PERFORMANCE TWIN-ENGINE AIRCRAFT [LES PROBLEMES D'INTEGRATION DE HELICES A LA CELLULE D'UN AVION ET, PLUS PARTICULIEREMENT, D'UN BIMOTEUR DE FORTE PUISSANCE]**
R. TAISSERIE *In* AGARD Aerodyn. and Acoustics of Propellers 10 p Feb. 1985 In FRENCH
Avail: NTIS HC A20/MF A01

This report presents studies conducted on the integration of aircraft propellers with the airframe for general aircraft, as well as for high performance twin engine propeller aircraft. The effect of engine dimensions on the aerodynamic characteristics of the aircraft in all flight situations, including low speed flight, is presented. It is shown that detailed model tests will have to be conducted before accurate results can be obtained. The objective of these studies is to examine possible configurations for future maritime reconnaissance twin engine propeller aircraft. T.M.

**N86-11166#** Lockheed-Georgia Co., Marietta.
**WIND TUNNEL INVESTIGATION OF THE INTERACTION OF PROPELLER SLIPSTREAM WITH NACELLE/WING/FLAP COMBINATIONS**
A. S. ALJABRI and A. C. HUGHES *In* AGARD Aerodyn. and Acoustics of Propellers 10 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

Until recently it was sufficient to define the propeller slipstream by the average velocity induced across the propeller disk. With the advent of the highly loaded program and the accompanying concern for the effect of the slipstream and its interaction with aircraft components be known. This paper describes a series of wind tunnel tests performed to improve the understanding of this complex aerodynamic interaction. The tests were conducted using a conventional propeller operating at low subsonic speeds. Complementary theoretical and experimental studies were used to investigate the interaction effects. Results from wind tunnel tests on propeller/nacelle/wing, and propeller/nacelle/wing/flap combinations are presented here. Force, pressure, and wake survey data from the test allow the slipstream characteristics, including its distortion by the wing and flap, to be obtained. The important parameters which govern the slipstream shape and induced velocities are identified and techniques are developed for estimating slipstream drag and the torque absorbed by a wing immersed in the slipstream. An improved understanding of the effects of wind tunnel walls on propeller powered testing is also presented. Author

**N86-11167*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AN ASYMPTOTIC THEORY FOR THE INTERFERENCE OF LARGE ASPECT RATIO SWEPT WINGS AND MULTIPLE PROPELLER SLIPSTREAMS**
R. K. PRABHU (Old Dominion Univ.), C. H. LIU, and S. N. TIWARI (Old Dominion Univ.) *In* AGARD Aerodyn. and Acoustics of Propellers 17 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 01A

This paper presents an asymptotic method for the analysis of the interference of multiple tractor propeller slipstream with large aspect ratio swept wings. It is assumed that the height of the slipstream is of the order of the wing chord and its spanwise extent is of the order of the wing span. Three different flow regions are identified by employing different stretching transformations. Asymptotic expansions are made in each of the three regions, using the chord to span ratio as the small expansion parameter. The details of the nonuniform flow in the slipstream enter into the wing sectional analysis. In the outer limit, the wing shrinks to a swept lifting line, and the slipstream reduces to a thin sheet of jet carrying the momentum gain from the propeller. The curvature of this jet sheet results in a pressure difference which is represented by a vortex sheet. The governing equations are solved by discretization. Several examples are considered for which experimental data are available. Comparison of the present results with the experimental data as well as other numerical solutions showed generally good agreement. Author

**N86-11168#** Carleton Univ., Ottawa (Ontario). Dept. of Mechanical and Aeronautical Engineering.
**DEVELOPMENT OF MODERN TURBOPROP ENGINES**
H. I. H. SARAVANAMUTTOO *In* AGARD Aerodyn. and Acoustics of Propellers 9 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

Proposals for propfan commercial aircraft operating at high cruise speeds pose requirements for advanced turboprops of high power. The history of turboprops for long range operation is briefly reviewed and the requirements for future engines are discussed. Considerable gains in the thermodynamic cycle can be realized, and the development of high performance gas generators should be a straightforward process. Transmission designs for high power engines may be extremely difficult and may result in novel engine configurations. It appears likely that a more modest goal of M = 0.7 cruise for shorter haul aircraft could be attained with much less risk while still achieving major gains. Author

**N86-11170#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
**SOME AEROACOUSTIC WIND TUNNEL MEASUREMENTS, THEORETICAL PREDICTIONS, AND FLIGHT-TEST CORRELATIONS ON SUBSONIC AIRCRAFT PROPELLERS**
W. J. G. TREBBLE, J. WILLIAMS (Southampton Univ., England), and R. P. DONNELLY (Dowty Rotol Ltd, Gloucester, England) *In* AGARD Aerodyn. and Acoustics of Propellers 21 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

Aeroacoustic experiments using the full scale propeller nacelle rig in the 24 ft anechoic tunnel were first made in 1979/80 on three alternative propellers also tested in flight on the Short's 330 aircraft. The Hartzell five bladed propeller of the production aircraft has conventional NACA 64 series sections and standard tips, the Hartzell Q-tip version of this has its tips bent as lower surface end plates in the direction of rotation, and the Dowty four bladed propeller has modern ARA-D sections and standard tips (D sub p = 2.8 m). Later complementary tunnel/flight experiments also included the Dowty four bladed R.212 propeller with classical NACA 16 series sections as fitted to the B.Ae. HS 748 aircraft (D sub p = 3.7 m). Author

**N86-11512*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**COMBUSTION HOT SECTION TECHNOLOGY**
D. B. ERCEGOVIC *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 129-133 Oct. 1983 refs
Avail: NTIS HC A11/MF A01 CSCL 21E

The overall objective of the Turbine Engine Hot Section Technology Combustion Project is to develop and verify improved and more accurate analysis methods for increasing the ability to design with confidence the combustion system for advanced aircraft turbine engines. The analysis methods developed will be generically applicable to combustion systems and not restricted to one specific engine or manufacturer. This project's approach was to first assess and evaluate existing combustor aerothermal analysis models by means of a contracted effort initiated during FY 1982. This evaluation effort has assessed and quantified known models' strengths and deficiencies. During FY 1984 the Aerothermal Modeling Program, Phase 2 will be initiated, which is expected to have contracted model development efforts in the areas of improved numerical methods for turbulent viscous flows, flow interactions, and fuel spray flow foekd interactions. A Phase 3 effort is planned to address remaining model deficiencies. The primary inhouse effort in this area will be the determination of high pressure flame radiation characteristics in a full annular combustor. This experiment will be conducted in the NASA LeRC High Pressure Facility with the results compiled into a comprehensive flame radiation and liner heat flux model. Author

**N86-11513*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**HOST STRUCTURAL ANALYSIS PROGRAM OVERVIEW**
R. H. JOHNS *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 153-158 Oct. 1983
Avail: NTIS HC A11/MF A01 CSCL 21E

Hot section components of aircraft gas turbine engines are subjected to severe thermal structural loading conditions, especially during the start up and take off portions of the engine cycle. The most severe and damaging stresses and strains are those induced by the steep thermal gradients induced during the start up transient. These transient stresses and strains are also the most difficult to predict, in part because of the temperature gradients and distributions are not well known or readily predictable, and also because the cyclic elastic viscoplastic behavior of the materials at these extremes of temperature and strain are not well known or readily predictable. A broad spectrum of structures related technology programs is underway to address these deficiencies. One element of the structures program is developing improved time varying thermal mechanical load models for the entire engine mission cycle from start up to shutdown. Another major part of the program is the development of new and improved nonlinear 3-D finite elements and associated structural analysis programs, including the development of temporal elements with time dependent properties to account for creep effects in the materials and components. Author

**N86-11515*#** General Electric Co., Cincinnati, Ohio.
**COMPONENT-SPECIFIC MODELING**
M. L. ROBERTS *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 165-173 Oct. 1983
(Contract NAS3-23687)
Avail: NTIS HC A11/MF A01 CSCL 21E

The overall objective of this program is to develop and verify a series of interdisciplinary modeling and analysis techniques which have been specialized to address three specific hot section components. These techniques will incorporate data as well as theoretical methods from many diverse areas, including cycle and performance analysis, heat transfer analysis, linear and nonlinear stress analysis, and mission analysis. Building on the proven techniques already available in these fields, the new methods developed through this contract will be integrated to provide an accurate, efficient, and unified approach to analyzing combustor burner liners, hollow air cooled turbine blades, and air cooled turbine vanes. For these components, the methods developed will predict temperature, deformation, stress, and strain histories throughout a complete flight mission. Author

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-10160**
**AN ANALYSIS OF TWO METHODS FOR ANALYSIS OF DYNAMIC FLIGHT TEST MANOEUVRES**
M. H. VERHAEGEN and J. VANDEWALLE (Leuven, Katholieke Universiteit, Heverlee, Belgium) International Journal of Modelling and Simulation (ISSN 0228-6203), vol. 5, no. 3, 1985, p. 94-99. Research supported by the Instituut tot Aanmoediging van het Wetenschappelijk Onderzoek in Nijverheid en Landbouw. refs

New, reliable flight test instrumentation systems and accurate data analysis methods are needed for the conduction of dynamic flight tests. The present study is concerned with the required data analysis methods, taking into account problems related to the

reconstruction of the aircraft motion (state), and to aircraft system model identification. Attention is given to two different methods for solving these problems in the case of linear aircraft model structures. The first method, referred to as the 'one-step method', is based on postflight data analysis. The second method relies on accurate measurements of specific aerodynamic forces and moments. Using the measurements of these aerodynamic quantities, the state of the aircraft is obtained on the basis of the solution of linear equations. The reconstructed state is used in a second step, involving the aerodynamic model identification.
G.R.

**A86-10371**

### DIGITAL FLIGHT CONTROL SYSTEMS FOR UMA

D. J. DYER (Cranfield Institute of Technology, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 25.1-25.9. Research supported by the Ministry of Defence (Procurement Executive).

The evolution of two microprocessor-based flight control systems for unmanned aircraft (UMA), the MACHAN, and the CRANFIELD Digital Flight Control System (DFCS) is described. The design goals for both systems are discussed in connection with the operating environment of next generation UMAs. Consideration is given to durability in the presence of EMI; versatility; and low-weight for maximum endurance. The CRANFIELD DFCS is currently under development for a next generation UMA system having applications in the fields of battlefield surveillance; weapons delivery; and target drones. The estimated volume, weight, and power consumption of the DFCS were 1/3 lower in comparison with the MACHAN system. A schematic diagram of the DFCS control loop is provided. I.H.

**A86-10931#**

### MODELING VEHICLE DYNAMICS FOR FLYING QUALITIES STUDIES

H. T. BREUL, T. L. KELLER, and R. C. WESTON (Grumman Corp., Bethpage, NY) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 11 p.
(AIAA PAPER 85-3062)

A convolution and superposition approach is described for defining numerical models for examining modern aircraft flying quality problems. The simulations are limited to small variations in speed and attitude about fixed, trimmed flight conditions. A main research goal is to evaluate pilot acceptance of control system performance in reference flight conditions. Linear models are used for the vehicle/system dynamics, yielding geometric outputs for the time responses to a unit step input of pilot control. The resulting motion signatures provide graphic data on the motion a pilot experiences in response to control actions. Convolution and superposition mathematical techniques form the bases for the CONVO code for the control qualities simulation-based research, which is illustrated by assessing the adverse lateral control responses of a hovering VTOL aircraft. M.S.K.

**A86-10942#**

### DIGITAL FLIGHT CONTROL OF LONGITUDINALLY UNSTABLE AIRCRAFT

A. BRADSHAW, A. T. DAVIS, and M. A. WOODHEAD (Salford, University, England) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 8 p. refs
(AIAA PAPER 85-3088)

A numerical examination is made of the effects of a gradual relaxation of stability of a YF-16 aircraft from an s-plane pole value of +1.18 at Mach 0.6 at sea level to a value of +5.0. The study is carried out in terms of the frequency response and root locus characteristics to which flight control systems must be retuned to maintain adequate response characteristics in unstable flight. Comparisons are made with the AFTI/F-16 response at Mach 0.6 at 3000 ft altitude, wherein the unstable pole has a value of +5.45. The results indicate that a single-input, pitch-rate controller will not be able to maintain longitudinal stability using current technologies. A faster iteration rate and a concomitant increase in the on-board processing power will ameliorate some of the control problems.
M.S.K.

**A86-10943#**

### ADAM - AN AEROSERVOELASTIC ANALYSIS METHOD FOR ANALOG OR DIGITAL SYSTEMS

T. NOLL, M. BLAIR, and J. CERRA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(AIAA PAPER 85-3090)

Coupling of the elastic modes and the high-gain automatic flight control systems of the aircraft can result in unstable interactions within the flight envelope. These instabilities are any undamped structural oscillations sensed by the flight controller and driven by the control surface motions. This paper highlights the activities pursued by the Flight Dynamics Laboratory (FDL) in developing analysis tools for performing independent audits of proposed flight systems and for conducting research in the area of aeroservoelasticity (ASE). ADAM (Analog and Digital Aeroservoelasticity Method) combines the technologies of unsteady aerodynamics, multiinput/multioutput (MIMO) controls and structural dynamics into an interactive analysis package. The governing equations and the results of several examples that were used to verify the credibility of ADAM are discussed in the paper. Lessons learned are included to help engineers avoid the unexpected.
Author

**A86-11061#**

### MISSION-ADAPTIVE WING CAMBER CONTROL SYSTEMS FOR TRANSPORT AIRCRAFT

J. H. RENKEN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. BMFT-sponsored research. refs
(AIAA PAPER 85-5006)

Based on the results of a current research program concerning variable wing camber control in future transport aircraft, the paper discusses some aspects of wing profile shaping and mechanical verification, which are essentially dominated by the aerodynamic requirements. A principle of chordwise and spanwise camber variation is exemplified and some targets and constraints relevant to variable camber schedules are outlined. Finally, some comments on integrating variable camber into an automatic flight control/management system are made. Author

**A86-11437#**

### SPECIFICATION AND REVIEW OF FLIGHT CRITICAL DIGITAL SYSTEMS

J. Y. HUNG (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) and H. HECHT (SoHaR, Inc., Los Angeles, CA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 252-258. refs
(AIAA PAPER 85-5097)

A synopsis of several sections of the Air Force Computer Resources Handbook for Flight Critical Systems is presented, including sections dealing with activities during the requirements phase, contractor surveillance, and the evaluation of flight critical systems. The handbook covers both management and technical concerns in the development of flight critical digital systems. It emphasizes the need for a precise definition of the scope of flight critical systems and calls attention to the cost impact if noncritical functions are made a part of the flight critical system.
B.J.

**A86-11439#**

**FAULT EFFECT PROTECTION AND PARTITIONING FOR FLY-BY-WIRE/FLY-BY-LIGHT AVIONICS SYSTEMS**

L. J. YOUNT, K. A. LIEBEL, and B. H. HILL (Sperry Corp., Commercial Flight Systems Div., Phoenix, AZ) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 275-284. refs
(AIAA PAPER 85-6002)

This paper discusses the special problems involved in developing full-time critical, (i.e., fly-by-wire/fly-by-light) fully digital, control systems for commercial transport aircraft. The starting point will be a discussion of critical (Category III) automatic landing systems, beginning with early, fully analog implementations and continuing through to current digital implementations, some of which are capable of tolerating generic software errors. Fault effects partitioning for both hardware and software will be discussed relative to perceived need, and several available techniques will be described. The emphasis of this paper will be an architectural solution to safety validation problems. The specific limitations of analysis-dependent validation techniques, such as RTCA/DO-178, will be discussed. Special emphasis will be given to extensive generic fault protection for fly-by-wire/fly-by-light systems through the use of fault-tolerance mechanisms including 'multi-version software'. Author

**A86-12294#**

**QUASI-OPTIMAL ON-LINE GUIDANCE LAWS FOR MILITARY AIRCRAFT**

H. T. HUYNH and O. MOREIGNE (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1985-91, 1985, 13 p. refs
(AIAA PAPER 85-1977; ONERA, TP NO. 1985-91)

Quasi-optimal guidance laws for on-board computation application have been developed for minimum-time to climb and intercept manoeuvers in the vertical plane. The technique used is derived from singular perturbation theory with a realistic times scale decomposition of the aircraft dynamics. The control laws obtained are of closed-loop type, and can fulfill terminal constraints on altitude and or flight path angle. The validity is extended to a large flight envelope by taking into account an intermediate boundary layer in order to eliminate the altitude-jump in energy-climb profile. These control laws are further corrected by a pseudo-first order asymptotic expansion and are compared in numerical simulations with the exact open loop solutions given by a projected gradient numerical algorithm. A better than 1 percent accuracy is obtained for the performance index. The computation time of these quasi-optimal laws is very small, and is compatible with real-time on-board computer applications. Author

**A86-12535**

**DETERMINATION OF THE ORDER AND STRUCTURE OF THE LINEAR DIFFERENTIAL EQUATIONS OF AIRCRAFT MOTION FROM EXPERIMENTAL RESULTS [OPREDELENIE PORIADKA I STRUKTURY LINEINYKH DIFFERENTSIAL'NYKH URAVNENII DVIZHENIIA SAMOLETA PO REZUL'TATAM EKSPERIMENTA]**

V. A. LEONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 38-42. In Russian.

Decision rules for estimating the order and structure of a linear differential equation describing experimental results are obtained by using the Bayes approach. The decision rules for estimating the order of the 'inputs' and 'outputs' of a system are related to the Akaike criterion. It is also noted that the decision rules obtained can be extended to the case of the r-dimensional vector 'input'. V.L.

**A86-12539**

**THE PROBLEM OF DETERMINING THE OPTIMUM PARAMETERS OF AN AUTOPILOT [K ZADACHE OPREDELENIIA OPTIMAL'NYKH PARAMETROV AVTOPILOTA]**

L. G. ROMANENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 56-60. In Russian. refs

The optimum parameters of an autopilot can be effectively determined by using the standard forms of characteristic polynomials. Here, algorithms are developed for determining the coefficients of characteristic polynomials corresponding to minimum integral quadratic estimates. The use of the results obtained for calculating the parameters of an autopilot is illustrated by an example. V.L.

**A86-12540**

**THE PROBLEM OF SELECTING THE PARAMETERS OF A FLIGHT VEHICLE ON THE BASIS OF THE MOTION STABILITY REQUIREMENT [K VOPROSU VYBORA PARAMETROV LETATEL'NOGO APPARATA IZ USLOVIIA OBESPECHENIIA USTOICHIVOSTI EGO DVIZHENIIA]**

T. K. SIRAZETDINOV and N. R. SURKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 61-64. In Russian. refs

The problem of selecting the parameters of a flight vehicle on the basis of the motion stability requirement is analyzed for the case where the flight vehicle motion is described by a system of linear differential equations with variable coefficients. The problem is treated as the main control problem, and a solution is obtained using the method of Liapunov functions. V.L.

**A86-12552**

**MODELING OF THE VARIABLE FRONTAL STIFFNESS OF THE RUDDER OF A DYNAMICALLY SIMILAR EMPENNAGE MODEL [MODELIROVANIE PEREMENNOI LOBOVOI ZHESTKOSTI RULIA DINAMICHESKI PODOBNOI MODELI OPERENIIA]**

A. V. STARIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 94, 95. In Russian.

The use of a three-dimensional deformation model in solving the problem of the flexure-rudder flutter of the empennage has shown that the critical velocity depends to a large extent on the stiffness of the rudder in the chord (frontal) plane. Here, a method is described for modeling the variable frontal stiffness of a rudder in order to determine its effect on the dynamic stability of an empennage model. The method consists in fabricating a series of rudder spars for a dynamically similar empennage model and investigating the effect of the frontal stiffness of the rudder on the critical flutter parameters. V.L.

**A86-12554**

**A DYNAMIC ANALYSIS OF THE DIMENSIONAL CHAINS OF AIRCRAFT CONTROL SYSTEMS [DINAMICHESKII ANALIZ RAZMERNYKH TSEPEI SISTEM UPRAVLENIIA LETATEL'NYKH APPARATOV]**

V. S. KHUKHOREV and V. O. VRUBLEVSKAIA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 98-100. In Russian.

The kinematics of the mechanisms of aircraft control systems is described by a mathematical model based on the theory of dimensional chains. The mathematical model represents a dynamic analysis of the dimensional chain of a control system formed by consecutively coupled assembly elements. The principal types of assembly elements are identified. V.L.

**A86-12557**

**A METHOD FOR THE MODAL SYNTHESIS OF AN AIRCRAFT LATERAL MOTION CONTROL LAW [METOD MODAL'NOGO SINTEZA ZAKONA UPRAVLENIIA BOKOVYM DVIZHENIEM SAMOLETA]**

A. O. BROITMAN and A. N. OBOTNIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 104-107. In Russian. refs

*A modal procedure for the synthesis of a control law for the lateral motion of an aircraft is developed in which decoupling is achieved by selecting the desired eigenvectors of a closed system.* The modal synthesis procedure proposed here is readily implemented in algorithms since all the steps of the procedure consist of solving systems of linear equations. The method can be used for the design of both analog and digital control systems. V.L.

**N86-10047#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abt. Flaechenflugzeuge.

**CONTROL CONCEPTS FOR IN-FLIGHT SIMULATION INCLUDING ACTUATOR NONLINEARITIES AND TIME DELAYS**

F. HENSCHEL Mar. 1985 69 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-948)
(DFVLR-FB-85-24; ISSN-0171-1342) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 23.50

A model-following system was developed to study the dynamic behavior of transport aircraft with reduced longitudinal stability. The system is divided into two parts. The first consists of feedforward branches. If a linear description of the model and the basic aircraft is assumed an exact model-following is achieved by this part. For the control matrices algebraic expressions are derived. In the equations the influence of actuator dynamics is considered. A set of formulas in which all variables are assumed to be discretized for processing on a digital computer is developed. By the second subsystem an error suppression is achieved. The application of a cost vector method is demonstrated for one example. It is shown that nonlinearities and time lags can be included in the calculation of the feedback gains. Author (ESA)

**N86-11203*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PRELIMINARY DESIGN STUDY OF A LATERAL-DIRECTIONAL CONTROL SYSTEM USING THRUST VECTORING**

F. J. LALLMAN Nov. 1985 51 p refs
(NASA-TM-86425; L-15990; NAS 1.15:86425) Avail: NTIS HC A04/MF A01 CSCL 01C

A preliminary design of a lateral-directional control system for a fighter airplane capable of controlled operation at extreme angles of attack is developed. The subject airplane is representative of a modern twin-engine high-performance jet fighter, is equipped with ailerons, rudder, and independent horizontal-tail surfaces. Idealized bidirectional thrust-vectoring engine nozzles are appended to the mathematic model of the airplane to provide additional control moments. Optimal schedules for lateral and directional pseudo control variables are calculated. Use of pseudo controls results in coordinated operation of the aerodynamic and thrust-vectoring controls with minimum coupling between the lateral and directional airplane dynamics. Linear quadratic regulator designs are used to specify a preliminary flight control system to improve the stability and response characteristics of the airplane. Simulated responses to step pilot control inputs are stable and well behaved. For lateral stick deflections, peak stability axis roll rates are between 1.25 and 1.60 rad/sec over an angle-of-attack range of 10 deg to 70 deg. For rudder pedal deflections, the roll rates accompanying the sideslip responses can be arrested by small lateral stick motions. E.A.K.

**N86-11204*#** Calspan Advanced Technology Center, Buffalo, N.Y.

**MISSION-ORIENTED REQUIREMENTS FOR UPDATING MIL-H-8501: CALSPAN PROPOSED STRUCTURE AND RATIONALE Final Report**

C. R. CHALK and R. C. RADFORD Sep. 1985 294 p refs
(Contract NAS2-11303; DA PROJ. 1L1-62209-AH-76-A)
(NASA-CR-177371; USAAVSCOM-TR-85-A-7; NAS 1.26:177371; CALSPAN-REPT-7097-F-1) Avail: NTIS HC A13/MF A01 CSCL 01C

This report documents the effort by Arvin/Calspan Corporation to formulate a revision of MIL-H-8501A in terms of Mission-Oriented Flying Qualities Requirements for Military Rotorcraft. Emphasis is placed on development of a specification structure which will permit addressing Operational Missions and Flight Phases, Flight Regions, Classification of Required Operational Capability, Categorization of Flight Phases, and Levels of Flying Qualities. A number of definitions is established to permit addressing the rotorcraft state, flight envelopes, environments, and the conditions under which degraded flying qualities are permitted. Tentative requirements are drafted for Required Operational Capability Class 1. Also included is a Background Information and Users Guide for the draft specification structure proposed for the MIL-H-8501A revision. The report also contains a discussion of critical data gaps and attempts to prioritize these data gaps and to suggest experiments that should be performed to generate data needed to support formulation of quantitative design criteria for the additional Operational Capability Classes 2, 3, and 4. Author

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-10366**

**A NOVEL LAUNCHER FOR R.P.V.S**

D. GRIFFIN (Frazer-Nash, Ltd., Kingston-upon-Thames, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 20.1-20.11. Research supported by the Ministry of Defence (Procurement Executive).

A flywheel-powered catapult launch system for RPVs has been developed. The system is mounted on the back of a truck and can be prepared for use in a minimum of five minutes. The salient features of the launch system design are illustrated including the flywheel drum arrangement, the motor driving the flywheel, and the electromagnetic brake system. The torque of the flywheel is equal to 80 percent of the acceleration tolerance limit of the RPV. The predicted performance envelopes for a ramp-clutch-flywheel launcher configuration are presented. I.H.

**A86-10367**

**LAUNCH AND RECOVERY OF AIRBORNE REMOTELY PILOTED VEHICLES**

G. R. VEAZEY, SR. (All American Engineering Co., Newark, DE) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 21.1-21.8.

The principle technologies associated with airborne and ground based RPV recovery and launch systems are briefly reviewed. Consideration is given to hydraulic/pneumatic (HP) launchers; and rocket-based launch systems. Among the recovery systems described are: the STARS net recovery system and a net recovery system incorporating rotary hydraulic kinetic energy absorbers. Black and white photographs of the different launch and recovery systems are provided. I.H.

**A86-10376**

**PORTABLE TACTICAL DISPLAY SYSTEMS FOR RPV'S**

I. GUY (Israel Aircraft Industries, Ltd., Tel Aviv) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Supplementary Papers . Bristol, University of Bristol, 1984, p. 19.1-19.5.

The design of a tactical display system, the Mobile Receiving Unit (MRU)-1000, for the Scout Mini-RPV (MRPV) is discussed. The uses, launch and recovery capabilities, and the ground control station of the Scout MRPV are described. The MRU-1000 is to receive and display, in real time, data transmitted by the Scout MRPV. The functioning of the MRU-1000, which receives television picture and telemetric data, is explained. The MRU-1000 consists of four assemblies: (1) antenna assembly, (2) receiver, (3) decoder and display assembly, and (4) plotter assembly; the components and functions of the assemblies are discussed. The use of the artillery adjustment mode is examined. I.F.

**A86-10955*#** Kansas Univ., Lawrence.
**DESIGN OF STATIC REACTION GANTRY FOR AN ULTRALIGHT AIRPLANE DESTRUCTION TEST**
H. W. SMITH (Kansas, University, Lawrence) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 7 p.
(Contract NAG1-345)
(AIAA PAPER 85-4022)

The steel gantry superstructure needed to perform an airplane static test is described. Standard civil engineering design practices are used to react the loads generated by an airplane in flight. Reaction columns are mounted on a structural floor to carry the wing airloads and the downward acting fuselage loads are carried directly into the floor. The gantry can accommodate a general aviation airplane or rotorcraft. An immediate use for an ultralight airplane is shown as an example configuration of the four main steel frames. Author

**A86-10966*#** California State Polytechnic Univ., Pomona.
**DEVELOPMENT AND USAGE OF A SMALL-SCALE V/STOL GROUND EFFECTS SIMULATOR**
P. A. LORD (California State Polytechnic University, Pomona) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 12 p. refs
(Contract NAG2-49)
(AIAA PAPER 85-4037)

A small scale ground effects simulator for V/STOL aircraft design testing has been built by an American university in association with NASA-AMES. The simulator is used to measure pressures and forces on a wide variety of V/STOL model configurations including generic models which do not represent any particular aircraft. The modes of operation and instrumentation of the simulator are described, and a survey of some recent test results are presented. The basic simulator consists of two parts, an aluminum disk ground plane and a model support. Instrumentation consists of pressure transducers, scanivalves, thermocouples and hot wire anemometers. Test results are presented for single and twin nozzle configurations; a generic V/STOL design, and the Harrier and Grumman 698 combat aircraft models. A black and white photograph of the simulator is provided. I.H.

**A86-11174#**
**EVALUATION OF A LOAD CELL MODEL FOR DYNAMIC CALIBRATION OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT**
R. W. DU VAL, M. BAHRAMI (Advanced Rotorcraft Technology, Inc., Los Altos, CA), and B. WELLMAN (U.S. Army, Research and Technology Laboratories, Moffett Field, CA) IN: Decennial Specialists' Meeting on Rotorcraft Dynamics, 2nd, Moffett Field, CA, November 7-9, 1984, Proceedings . Alexandria, VA, AHS, 1984, 14 p. refs

The Rotor Systems Research Aircraft uses load cells to isolate the rotor/transmission system from the fuselage. An analytical model of the relationship between applied rotor loads and the resulting load cell measurements is derived by applying a force-and-moment balance to the isolated rotor/transmission system. The model is then used to estimate the applied loads from measured load cell data, as obtained from a ground-based shake test. Using nominal design values for the parameters, the estimation errors, for the case of lateral forcing, were shown to be on the order of the sensor measurement noise in all but the roll axis. An unmodeled external load appears to be the source of the error in this axis. Author

**A86-11775**
**HELICOPTER MONTAGE OF A PATH ANTENNA SETUP FOR THE INSTRUMENTAL LANDING SYSTEM SP 70 AT DRESDEN AIRPORT [HUBSCHRAUBERMONTAGE DER KURSWEGANTENNENANLAGE DES INSTRUMENTENLANDESYSTEMS SP 70 AUF DEM FLUGHAFEN DRESDEN]**
W. TREMPLER Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 4, 1985, p. 126-131. In German.

**N86-10048*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**MANNED FLIGHT SIMULATION: CHALLENGE AND RESPONSE**
J. C. DUSTERBERRY Sep. 1985 10 p refs
(NASA-TM-86827; REPT-85392; NAS 1.15:86827) Avail: NTIS HC A02/MF A01 CSCL 14B

Early AGARD papers on manned flight simulation describe the status of an emerging test technique and then offer suggestions of problems that should be solved to advance the technique and predictions of the results that will be obtained by its use. Later AGARD literature is examined to determine how these challenges have been met, both in ground-based and in-flight simulation and how AGARD has played an important role in advancing the technique so that it is now an integral part of the aerospace vehicle design process. Author

**N86-10049#** Sandia National Labs., Albuquerque, N. Mex.
**SIMULATED DIRECT-STRIKE LIGHTNING TESTING AT SANDIA NATIONAL LABORATORIES**
G. L. MAXAM 1985 10 p Presented at the Intern. Symp. on Electromagnetic Compatibility, Wakefield, Miss., 20 Aug. 1985
(Contract DE-AC04-76DP-00789)
(DE85-012033; SAND-85-0063C; CONF-850884-1) Avail: NTIS HC A02/MF A01

The design of the Sandia Lightning Simulator is described and its capabilities are summarized. The approach generally used in testing components and systems including the instrumentation used for test item diagnostics and for data acquisition is also described. Several applications of the simulator test capabilities are examined including Sandia systems, Navy aircraft and an ALCM missile. Some future directions now envisioned are discussed. DOE

**N86-11205** Communications Research Centre, Ottawa (Ontario). Space Technology and Applications Branch.
**CRC CONTROL SYSTEMS LABORATORY GYRO TEST FACILITY**
W. S. MCMATH and S. K. YEUNG Apr. 1985 21 p
(CRC-1385) Avail: Issuing Activity

The gyro test facility was developed to provide a high precision testing capability, with the versatility to simulate, monitor and analyze the performance of a wide variety of sensors. The technical features of the facility as it was developed in parallel with a Single-Degree-of-Freedom (SDOF) gyro test program are summarized. Some of the data from that test program is included as a working example of facility capability. However, the details of the complete gyro evaluation will be covered in a separate report. Author

**N86-11207*#** Boeing Aerospace Co., Seattle, Wash.
**LASER ANGLE SENSOR**
C. R. POND and P. D. TEXEIRA Sep. 1985 184 p refs
(Contract NAS1-16546)
(NASA-CR-172369; NAS 1.26:172369) Avail: NTIS HC A09/MF A01 CSCL 20E

A laser angle measurement system was designed and fabricated for NASA Langley Research Center. The instrument is a fringe counting interferometer that monitors the pitch attitude of a model in a wind tunnel. A laser source and detector are mounted above the model. Interference fringes are generated by a small passive element on the model. The fringe count is accumulated and displayed by a processor in the wind tunnel control room. This report includes optical and electrical schematics, system maintenance and operation procedures. Author

**N86-11208*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**VISUAL AND MOTION CUEING IN HELICOPTER SIMULATION**

R. S. BRAY Sep. 1985 19 p refs

(NASA-TM-86818; REPT-85371; NAS 1.15:86818) Avail: NTIS HC A02/MF A01 CSCL 14B

Early experience in fixed-cockpit simulators, with limited field of view, demonstrated the basic difficulties of simulating helicopter flight at the level of subjective fidelity required for confident evaluation of vehicle characteristics. More recent programs, utilizing large-amplitude cockpit motion and a multiwindow visual-simulation system have received a much higher degree of pilot acceptance. However, none of these simulations has presented critical visual-flight tasks that have been accepted by the pilots as the full equivalent of flight. In this paper, the visual cues presented in the simulator are compared with those of flight in an attempt to identify deficiencies that contribute significantly to these assessments. For the low-amplitude maneuvering tasks normally associated with the hover mode, the unique motion capabilities of the Vertical Motion Simulator (VMS) at Ames Research Center permit nearly a full representation of vehicle motion. Especially appreciated in these tasks are the vertical-acceleration responses to collective control. For larger-amplitude maneuvering, motion fidelity must suffer diminution through direct attenuation through high-pass filtering washout of the computer cockpit accelerations or both. Experiments were conducted in an attempt to determine the effects of these distortions on pilot performance of height-control tasks. Author

**N86-11210#** Engineering and Economics Research, Inc., Vienna, Va.

**ENHANCED AIRPORT SURFACE DETECTION EQUIPMENT APPLICATIONS**

H. R. SCHRAMM 17 Apr. 1985 72 p

(AD-A157641) Avail: NTIS HC A04/MF A01 CSCL 17G

The National Airspace Review (NAR) Enhancement Program is a cooperative government/industry effort to review airspace allocations and the procedural and regulatory aspects of scheduled improvements envisioned under the National Airspace System (NAS) Plan as well as other plans. Its purpose is to identify long-term operational considerations of enhanced systems as they evolve. Improved capabilities resulting from equipment already developed or in the process of development will be examined, with attention being focused on operational considerations rather than specific generation of system requirements. Task Group 4-6.1 of the NAR Enhancement Program convened in Washington, D.C., from January 8 to 10, 1985, and January 29, 1985. This task group was responsible for reviewing and analyzing operational considerations based on the development of enhanced airport surface detection equipment. The recommendations contained herein will be submitted to the Administrator, Federal Aviation Administration, through the NAR Enhancement Executive Steering Committee (EXCOM), for consideration and disposition. GRA

# 10

# ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-11768**

**AERODYNAMICALLY LANDING REENTRY VEHICLES [AERODYNAMISCH LANDENDE WIEDEREINTRITTSFAHRZEUGE]**

I. WIDJAJA (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) (Hermann-Oberth-Gesellschaft, Symposium ueber Gefluegelte Raumfahrzeuge, Hanover, West Germany, May 25, 1984) Astronautik (ISSN 0004-6221), vol. 22, no. 1, 1985, p. 16-19. In German.

The considered type of reentry vehicle has the capability to utilize aerodynamic forces and moments for achieving control over its flight path. It is, therefore, possible to reduce or limit the thermal and mechanical stresses to which the vehicle is subjected during its reentry in the atmosphere. The vehicle can be guided to a given landing location, and the reentry window can be enlarged. The considered capabilities are characterized by the lift drag ratio, and a certain price has to be paid for obtaining them. This price is related to a higher structural weight and more complex navigation and guidance systems. For this reason, the lift drag ratio represents a parameter which plays an important part in system optimization considerations. The effect of the lift drag ratio on parameters related to the flight path of the vehicle is considered along with the effect of this ratio on thermal flow phenomena. Attention is given to various reentry vehicle configurations, the results of experimental measurements, and aspects of longitudinal stability and controllability. G.R.

**A86-11769**

**AERODYNAMICALLY LANDING REENTRY VEHICLES [AERODYNAMISCH LANDENDE WIEDEREINTRITTSFAHRZEUGE]**

I. WIDJAJA (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) (Hermann-Oberth-Gesellschaft, Symposium ueber Gefluegelte Raumfahrzeuge, Hanover, West Germany, May 25, 1984) Astronautik (ISSN 0004-6221), vol. 22, no. 2, 1985, p. 39-41. In German.

This article represents a continuation of a paper in the preceding edition of this journal. The longitudinal stability of the reentry vehicle configuration 24B is discussed, taking into account an evaluation of the possibilities for lateral control, aileron effectiveness, and rudder effectiveness. It is pointed out that regarding the selection of the characteristics of the descent trajectory, there are apparently no constraints related to stability or controllability limits. In the hypersonic range, large reciprocal lift drag ratios can also be obtained without positive flap displacement. Attention is given to angle of sideslip relations, a cylindrical body with flat nose and trim tabs, the flow characteristics in the case of a cylinder with a flat nose, graphical relations describing longitudinal stability and controllability in the hypersonic range, and relations involving lift, drag, and the lift drag ratio. G.R.

**N86-10005#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THEORETICAL SPECIFIC IMPULSE FOR TWO-PHASE FLOW IN NOZZLE OF ROCKET-RAMJET ENGINE: A SIMPLE ESTIMATION METHOD**

B. SHIGUAN (China Precision Machinery Co.) *In its* Acta Aeron. et Astronautica Sinica (FTD-ID(RS)T-1120-84) p 53-60 4 Oct. 1984 refs Transl. into ENGLISH from Hangkong Xuebao (China), v. 4, no. 4, 1984 p 101-104
Avail: NTIS HC A04/MF A01 CSCL 21H

A theoretical specific impulse formula is derived for two phase flow in nozzle rocket ramjet engine on the basis of similarity to that used for rocket engines. Theoretically, it is proved that the properties of two phase flow in nozzle for these two types of engines can be analyzed with a common combined parameter which is equivalent to the exhaust velocity. A simple estimation method is introduced for specific impulse losses of two phase flow with variable lag. An approximate solution is proposed to deal with the problem of singularity. Author

**N86-11216*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

**HEAVY LIFT LAUNCH VEHICLES FOR 1995 AND BEYOND**

R. TOELLE, comp. Sep. 1985 149 p refs
(NASA-TM-86520; NAS 1.15:86520) Avail: NTIS HC A07/MF A01 CSCL 22B

A Heavy Lift Launch Vehicle (HLLV) designed to deliver 300,000 lb to a 540 n mi circular polar orbit may be required to meet national needs for 1995 and beyond. The vehicle described herein can accommodate payload envelopes up to 50 ft diameter by 200 ft in length. Design requirements include reusability for the more expensive components such as avionics and propulsion systems, rapid launch turnaround time, minimum hardware inventory, stage and component flexibility and commonality, and low operational costs. All ascent propulsion systems utilize liquid propellants, and overall launch vehicle stack height is minimized while maintaining a reasonable vehicle diameter. The ascent propulsion systems are based on the development of a new liquid oxygen/hydrocarbon booster engine and liquid oxygen/liquid hydrogen upper stage engine derived from today's SSME technology. Wherever possible, propulsion and avionics systems are contained in reusable propulsion/avionics modules that are recovered after each launch. Author

## 11

## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-10145#**

**NEW WORLD FOR AEROSPACE COMPOSITES**

W. F. DEMARIO (Northrop Corp., Materials and Process Engineering Section, Ventura, CA) Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1985, p. 36-40, 42.

The applications of composites in aerospace designs are discussed. A description and an explanation of the organic and metal-matrix composites and the reinforcements used in the spacecraft industry are presented. The structural applications for organic and metal-matrix composites for spacecraft are described. Examples of their use in a primary truss assembly, upper and lower cradle assemblies, tubular struts, forward adapter and the engine support of the structure of the Shuttle are provided. The composition and function of the forward adapters of the Shuttle/Centaur and the booms of the Shutttle's remote manipulator system are described. The advantages, applications, and design improvements of thin-ply carbon-carbon are examined. The characteristics of thermoplastic polymers are explained. The development of a new composite which combines aramid and aluminum in a laminate is discussed. I.F.

**A86-10364**

**SOME FABRICATION EXPERIMENTS TOWARDS A COMPOSITE RPV WING**

K. A. JACOB, B. S. RANGASHAYI, J. JAYARAMAN, and R. PERAVALI (Aeronautical Development Establishment, Structures and Materials Div., Bangalore, India) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 16.1-16.10.

A study is made on the various aspects of composite wing construction. The criteria for employing new materials and new construction concepts are discussed. Experimental wings are fabricated usingn glass-epoxy skin and polyurethane rigid foam core and metallic inserts for load introduction. This fabrication process resulted in producing complex contoured wing with minimum investment in tooling and processing. Improved construction based on monolithic construction is also outlined. Autho

**A86-11397*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EVALUATION OF EXPERIMENTAL EPOXY MONOMERS**

W. T. HODGES, T. L. ST. CLAIR (NASA, Langley Research Center, Hampton, VA), J. R. PRATT, and R. FICKLIN (Mississippi University for Women, Columbus) SAMPE Quarterly (ISSN 0036-0821), vol. 17, Oct. 1985, p. 21-25. Previously announced in STAR as N85-26996. refs

Future generation aircraft need higher performance polymer matrices to fully achieve the weight savings possible with composite materials. New resins are being formulated in an effort to understand basic polymer behavior and to develop improved resins. Some polymer/curing agent combinations that could be useful are difficult to process. In the area of epoxies, a major problem is that some components have physical properties which make them difficult to utilize as matrix resins. A previous study showed that the use of ultrasonic energy can be advantageous in the mixing of curing agents into a standard epoxy resin, such as MY 720 (Ciba-Geigy designation). This work is expanded to include three novel epoxides. R.J.F.

**A86-11645#**

**ON THE RELATIONSHIP BETWEEN FLAME STABILITY AND DRAG OF BLUFF-BODY FLAMEHOLDERS**

N. K. RIZK and A. H. LEFEBVRE (Purdue University, West Lafayette, IN) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 393-398. refs

The main purpose of the investigation is to establish a relationship between the blowoff velocity of a bluff-body flameholder and its drag coefficient. To this end numerous measurements of blowoff velocity and drag coefficient are carried out on various forms of two-dimensional flameholder. They include conventional V-gutters of the type widely employed in turbojet afterburners, and also 'single-sided' flameholders which are characterized by a single-vortex flow pattern in their wake region. The test program covers wide ranges of effective pressure ratio, obtained using the water injection technique, and also includes variations in velocity, flameholder size and flameholder blockage. The results confirm previous findings in regard to the strong influence of drag coefficient on blowoff velocity. They also provide a satisfactory explanation for the previously-reported superior flameholding properties of single-vortex systems over double-vortex systems. Author

## 11 CHEMISTRY AND MATERIALS

**A86-11694#**

### PROBLEMS OF IGNITION CORRELATIONS - AN ASSESSMENT OF APPLICATIONS TO REAL COMBUSTORS

J. ODGERS and D. KRETSCHMER (Universite Laval, Quebec, Canada) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 775-782. refs

The complexity of the ignition process as applied to gas turbine combustors is discussed with reference to the published experimental results and theoretical descriptions. All existing models can be subdivided into two processes: (1) the determination of the liberated spark energy, and (2) the progress of the spark kernel towards successful ignition, but no theoretical model can fully predict these processes quantitatively. The existing empirical and semiempirical ignition correlation formulas can be used for qualitative predictions only, unless a baseline can be established from experimental data. In this case quantitative predictions are sometimes possible within a standard deviation of about 20 percent. I.S.

**A86-11698#**

### COMBUSTION AND EMISSIONS PERFORMANCE OF A RAPID FUEL AND AIR MIXING COMBUSTOR

N. A. AL-DABBAGH, G. E. ANDREWS, and A. R. SHAHABADI (Leeds, University, England) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 804-812. refs

(Contract SERC-GR/A/76894; SERC-GR/B/92812)

A rapid jet mixing combustion system for gas turbine primary zones, with characteristics of low NO(x) and high combustion efficiency, has been developed. This 'jet mix' combustor consists of an array of radial air jets which impinge into an equal number of axial air jets. Fuel is injected in the center of the radial jets. The influence of the proportion of radial air is investigated and shown to have a strong influence on the overall fuel and air mixing rates with a consequent influence on flame stability and NO(x) emissions. It is shown that for 30 percent of the total air in the radial jet, the NO(x) emissions with direct propane injection are at a minimum and close to the premixed situation. Author

**A86-11734**

### A TYPE OF WIRE FOR COMPOSITES [VID PROVOLOKI DLIA KOMPOZITNYKH MATERIALOV]

A. A. KLEKOVKIN, A. G. CHUSOV, N. A. KLEKOVKINA, and S. A. OGOLIKHIN (Beloretskii Metallurgicheskii Kombinat, Beloretsk; Vsesoiuznyi Nauchno-Issledovatel'skii Institut Aviatsionnykh Materialov; AN SSSR, Institut Metallurgii, Moscow, USSR) Mekhanika Kompozitnykh Materialov (ISSN 0203-1272), July-Aug. 1985, p. 729, 730. In Russian.

Technical requirements are formulated for steel wire used as reinforcement in aluminum-matrix composites. A process for manufacturing stainless steel wire with a tensile strength in excess of 3500 MPa is then presented. The wire, which is made of 18Kh15N5AM3 steel, is used in composites with cold-curing adhesives for the fabrication of the torsion bar of the main rotor of helicopters. V.L.

**A86-12311#**

### STATE-OF-ART AND PROSPECTS OF CASTING TURBINE BLADES

K. YUNG (Chinese Aeronautical Establishment, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, June 1985, p. 201-207. In Chinese, with abstract in English. refs

This paper reviews the state-of-art and history of superalloys and casting turbine blades of aircraft engines in China since 1956. During this time the materials technologists and foundrymen have met the demands of aircraft engines with ever-developing cast-alloys and casting processes for turbine blades. Remarkable successes have been made in fields such as cast rotor blades, ceramic core for hollow channel blades, dispersion-strengthening of Ni-base alloys, computer-based quality control, etc. In view of the prospective advanced gas turbines, ceramic and refractory materials should be developed to meet the requirements of increased operating temperatures (1400 to 1600 C for metallic structure, enhanced surface stability, and superior mechanical properties. Super-alloys will serve in engine components at 550 to 1150 C in the foreseeable future; therefore, it is worth improving refractory metal molds and vacuum die casting to produce the advanced superalloy blades instead of conventional casting processes. Author

**A86-12313#**

### APPROACHES TO DEVELOPMENT OF COMPOSITE MATERIALS FOR AVIATION INDUSTRY IN CHINA

T. FAN (Beijing Institute of Aeronautical Materials, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, June 1985, p. 223-229. In Chinese, with abstract in English. refs

The state-of-art of composite materials in China is reviewed. Emphasis is put on the technical problems to be studied preferentially for exploitation of composite materials in aviation industry, for example, the seriation of intermediate materials production, the familiarization of fabrication techniques, the rationalization and optimization of composite design, and the establishment of quality assurance system. Principal tasks to be done in these fields and guidelines and directions to be followed are discussed in detail. Theoretical topics related closely to the solution of practical problems are suggested, and attention is called to research works on metal matrix composites. It is expected that the development of composite materials in China will be accelerated by way of proper use of successful foreign experience. Author

**A86-12314#**

### DIRECTIONALLY SOLIDIFIED BLADE SUPERALLOY DZ-22

L. WANG, R. CHEN, and Y. WANG (Beijing Institute of Aeronautical Materials, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, June 1985, p. 236-242. In Chinese, with abstract in English. refs

The directionally solidified (DS) superalloy DZ-22 possesses rather high mechanical properties at both intermediate and high temperatures, for instance, its stress-rupture strength for 100 h at 760 C and 1040 C are 804 MPa and 139 MPa, respectively. Its properties are comparable with the wel known DS superalloy PWA1422; therefore, it is applicable to advanced aircraft engine blades. The chemical composition of DZ-22 is based on the composition of PWA1422, but the content ranges of hafnium and carbon have been readjusted according to experimental results, so its hafnium content is limited in 1.2-2.0 wt pct instead of 1.5-2.5 wt pct and its carbon content is 0.12-0.16 wt pct rather than 0.08-0.14 wt pct. In addition, no zirconium is added intentionally in the alloy. The test results show that the shell-mold with drawn rate during the DS process affects the orientation of columnar crystals. The suitable drawn rate has been established about 7 mm/min. Enhancement of solution temperature during heat treatment can improve stress-rupture life at both 980 C and 1040 C, while the elongation decreases slightly. A pretreatment at 1150 C prior to the solution treatment can raise the incipient melting temperature. Author

**A86-12584**

### TEMPERATURE DEPENDENCE OF INCLUSION-FRACTURE-RELATED ACOUSTIC EMISSIONS IN 7075-T651 ALUMINUM

S. L. MCBRIDE and J. HARVEY (Royal Military College of Canada, Kingston) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S220-S223. Research supported by the Defence Research Establishment Pacific. refs

Variations in the acoustic emissions (AE) emitted by crack growth in aerospace Al alloys were studied over a temperature range of -40 C to 120 C, i.e., within the operational range of aircraft. The data recorded included peak AE amplitudes and crack lengths measured by the potential drop technique. The Al specimens were subjected to cyclic fatigue loading over the entire temperature range. The crack growth rate followed a quadratic equation with increasing temperature. Subsequent metallographic examinations indicated that the increase in the number of AE events with crack lengthening was associated with misfit stress effects at the inclusion-matrix interface. M.S.K.

**A86-12607**
**FULL-SCALE TESTING OF THE VNII NP-261 LUBRICANT [EKSPLUATATSIONNYE ISPYTANIIA SMAZKI VNII NP-261]**
S. L. SHADKINA, O. N. PUNKTOVA, and N. IA. CHERTKOVA (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Grazhdanskoi Aviatsii, Moscow, USSR) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 9, 1985, p. 29, 30. In Russian.

Flight test results are reported for a new lubricant, VNII NP-261, developed for use in the wheel bearings of the landing gear of aircraft instead of the lubricant NK-50, which no longer satisfies service requirements. An analysis of test results indicates that the new lubricant ensures satisfactory operation of the wheel bearings of the landing gear of commercial aircraft and helicopters at ambient temperatures from -55 to +45 C. V.L.

**N86-11249*#** Lockheed-Georgia Co., Marietta.
**ADHESIVES FOR AEROSPACE**
L. E. MEADE *In* NASA. Langley Research Center Welding, Bonding and Fastening, 1984 p 339-349 Sep. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 11A

The industry is hereby challenged to integrate adhesive technology with the total structure requirements in light of today's drive into automation/mechanization. The state of the art of adhesive technology is fairly well meeting the needs of the structural designers, the processing engineer, and the inspector, each on an individual basis. The total integration of these needs into the factory of the future is the next collective hurdle to be achieved. Improved processing parameters to fit the needs of automation/mechanization will necessitate some changes in the adhesive forms, formulations, and chemistries. Adhesives have, for the most part, kept up with the needs of the aerospace industry, normally leading the rest of the industry in developments. The wants of the aerospace industry still present a challenge to encompass all elements, achieving a totally integrated joined and sealed structural system. Better toughness with hot-wet strength improvements is desired. Lower cure temperatures, longer out times, and improved corrosion inhibition are desired. Author

**N86-11270*#** American Cyanamid Co., Stamford, Conn. Chemical Research Div.
**RECENT DEVELOPMENTS IN POLYIMIDE AND BISMALEIMIDE ADHESIVES**
R. E. POLITI *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 125-136 Sep. 1985
Avail: NTIS HC A18/MF A01 CSCL 11B

Research on high temperature resin systems has intensified. In the Aerospace Industry, the motivation for this increased activity has been to replace heat resistant alloys of aluminum, stainless steel and titanium by lighter weight glass and carbon fiber reinforced composites. Applications for these structures include: (1) engine nacelles involving long time exposure (thousands of hours) to temperatures in the 150 to 300 C range, (2) supersonic military aircraft involving moderately long exposure (hundreds of hours) to temperatures of 150 to 200 C, and (3) missile applications involving only brief exposure (seconds or minutes) to temperatures up to 500 C and above. Because of fatigue considerations, whenever possible, it is preferable to bond rather than mechanically fasten composite structures. For this reason, the increased usage of high temperature resin matrix systems for composites has necessitated the deviopment of compatible and equally heat stable adhesive systems. The performance of high temperature epoxy, epoxy phenolic and condensation polyimide adhesives is reviewed. This is followed by a discussion of three recently developed types of adhesives: (1) condensation reaction polyimides having improved processing characteristics; (2) addition reaction polyimides; and (3) bismaleimides. Author

**N86-11281*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**SURFACE PROTECTION OF GRAPHITE FABRIC/PMR-15 COMPOSITES SUBJECTED TO THERMAL OXIDATION**
M. P. HANSON and T. T. SERAFINI *In its* High Temp. Polymer Matrix Composites p 287-297 Sep. 1985 refs
Avail: NTIS HC A18/MF A01 CSCL 11D

Graphite fabric/PMR-15 laminates develop matrix cracks during long-term exposure in air at temperatures in the range of 500 to 600 F. This study was performed to demonstrate the effectiveness of incorporating graphite mat surface plies as a means of reducing the developing of matrix cracks. Celion 3000 graphite fabric/PMR-15 laminates were fabricated with graphite or graphite mat/325-mesh boron powder surface plies. Laminates without mat surface plies were also fabricated for control purposes. Composite flexural strength, flexural modulus, and interlaminar shear strength were determined at 288 C before and after long-term exposure (up to 1500 hr) in air at 316 C. The results of this study showed that the incorporation of graphite mat surface plies reduces matrix cracking and improves the elevated temperature mechanical property retention characteristics of the composites. Author

**N86-11283*#** General Dynamics/Convair, San Diego, Calif.
**EFFECTS OF REAL-TIME THERMAL AGING ON GRAPHITE/POLYIMIDE COMPOSITES**
J. F. HASKINS and J. R. KERR *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 315-327 Sep. 1985 refs
(Contract NAS1-12308)
Avail: NTIS HC A18/MF A01 CSCL 11D

As part of a program to evaluate high-temperature advanced composites for use on supersonic cruise transport aircraft, two graphite/polyimide composites have been aged at elevated temperatures for times up to 5.7 years. Work on the first, HT-S/710 graphite/polyimide, was started in 1974. Evaluation of the second polyimide, Celion 6000/LARC-160, began in 1980. Baseline properties are presented, including unnotched and notched tensile data as a function of temperature, compression, flexure, shear, and constant-amplitude fatigue data at R = 0.1 and R = -1. Tensile specimens were aged in ovens where pressure and aging temperatures were controlled for various times up to and including 50,000 hours. Changes in tensile strength were determined and plotted as a function of aging time. The HT-S/710 composite aged at 450 F and 550 F if compared to the Celion 6000/LARC-160 composite aged at 350 F and 450 F. After tensile testing, many of the thermal aging specimens were examined using a scanning electron microscope. Results of these studies are presented, and changes in properties and degradation mechanisms during high-temperature aging are discussed and illustrated using metallographic techniques. Author

**N86-11284*#** Boeing Commercial Airplane Co., Seattle, Wash.
**ENVIRONMENTAL STABILITY GRAPHITE/PMR-15 COMPOSITES**
C. H. SHEPPARD and D. MCLAREN *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 329-334 Sep. 1985 refs
Avail: NTIS HC A18/MF A01 CSCL 11D

During the past few years the Boeing Company was screening graphite composites for use in hot areas of engine nacelle structure. Structural and thermal analyses have shown that there is the potential for a 25 to 30 percent weight savings by using a graphite polyimide (Gr/PI) composite material in this type of structure. Work conducted on the NASA CASTS program (Composites for Advanced Space Transportation Systems) amply demonstrated the capability of Graphite/PMR-15 for short term service (125 hours) at temperatures up to 589 K (600 F). In addition, the CASTS program demonstrated that large structures could be fabricated using Gr/PMR-15. In commercial applications, however, the requirement exists for long term service capability (tens of thousands of hours) at temperatures ranging upwards from 449 K (350 F). The results of Graphite/PMR-15 materials characterization efforts conducted at Boeing are presented with emphasis on materials properties after isothermal aging at temperatures of 449 K (350 F) and above. Author

**N86-11285*#** Boeing Commercial Airplane Co., Seattle, Wash.
**DEVELOPMENT OF DESIGN DATA FOR PROPULSION PMR-15 COMPOSITES**
J. POSTLEWAITE and D. MCLAREN *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 335-338 Sep. 1985
Avail: NTIS HC A18/MF A01 CSCL 11D

The continuing develoment of PMR-15 composite materials and their associated design properties is pacing the implementation of this technology on commercial aircraft. The guidelines that the FAA has issued regarding the certification of advanced composite structures are very significant with respect to future PMR-15 research and development activities. The FAA has issued an advisory circular dated 1-5-83 concerning guidelines for composite aircraft structures. Of particular significance to PMR-15 technology development is the reliance on combined environmental exposure and component testing, coupled with the stipulation that reliance on previous experience be limited to where common structures and materials have been used for a similar function. Critical environmental exposures for commercial propulsion structures include 50,000 cycle service life, exposure to skydrol, moisture and other fluids, and nacelle fire conditions. G.L.C.

**N86-11289*#** Boeing Commercial Airplane Co., Seattle, Wash.
**APPLICATION OF GR/PMR-15 TO COMMERCIAL AIRCRAFT**
J. POSTLEWAITE, K. PORTER, and D. MCLAREN *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 393-400 Sep. 1985
Avail: NTIS HC A18/MF A01 CSCL 11D

Following from early experience with polyimides on the SST program and Shuttle aft flap studies the Boeing Company is now working on collaborative programs with its principal nacelle suppliers to pursue the development of Gr/PMR-15 nacelle components. Two programs are currently in effect. The first program is directed specifically towards the flight test and service evaluation at the earliest possible date of a 747 nacelle core cowl structure. The second program seeks to firmly establish the producibility and cost of a 757 thrust reverser C duct in a production environment. The near term objectives of these programs include: (1) the comparison of estimated cost and weight of Gr/PMR-15 versus metal structure, (2) the engine test of representative composite structure, (3) the preliminary design and analysis of the C duct structure, and (4) the preparation of cost data and time schedules for the development and producibility program. In addition to powerplant structure, the propulsion ducting system has shown to be a strong candidate for Gr/PMR-15 application. Currently, the Boeing 747 Organization is evaluating the use of PMR-15 matrix composites to replace nearly 800 lbs of titanium ducting per airplane. Author

**N86-11290*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
**FABRICATION PROCESS OF A HIGH TEMPERATURE POLYMER MATRIX ENGINE DUCT**
R. D. PRATT and A. J. WILSON *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 401-407 Sep. 1985
Avail: NTIS HC A18/MF A01 CSCL 11D

The process that was used in the molding of an advanced composite outer by-pass duct planned for the F404 engine is discussed. This duct was developed as a potential replacement for the existing titanium duct in order to reduce both the weight and cost of the duct. The composite duct is now going into the manufacturing technology portion of the program. The duct is fabricated using graphite cloth impregnated with the PMR-15 matrix system. G.L.C.

**N86-11291*#** Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
**CURRENT AND FUTURE ENGINE APPLICATIONS OF GR/PI COMPOSITES**
P. J. CAVANO and T. E. SCHMID *In* NASA. Lewis Research Center High Temp. Polymer Matrix Composites p 409-416 Sep. 1985
Avail: NTIS HC A18/MF A01 CSCL 11D

The application of organic matrix composites to gas turbine engine components has been the subject of numerous government and company funded programs since the 1960's. The possibility of significant weight reductions, performance improvements and lower component costs have made the organic matrix composites extremely attractive to aircraft engine designers. Very little of this potential was incorporated into production engines over the years even though a significant number of components were designed, fabricated and tested. Some of the reasons behind the slow rate of incorporation include the following: (1) criticality; (2) engine operating temperature; (3) small component size; (4) small production volume; (5) high production cost; and (6) interfacing with metal parts. G.L.C.

**N86-11315#** Department of the Navy, Washington, D. C.
**CHEMICAL BONDING AGENT FOR SUPPRESSION OF RUSTY BOLT INTERMODULATION INTERFERENCE Patent Application**
J. C. COOPER, inventor (to Navy) 23 Apr. 1985 20 p
(AD-D011747; US-PATENT-APPL-SN-726563) Avail: NTIS HC A02/MF A01 CSCL 20C

Intermodulation interference (IMI) occurrs when high frequency (HF) transmitters and receivers are placed in close proximity, particularly on ships and aircraft, due to non-linear conduction through metal-oxide-metal (MOM) junctions in the supporting structure. Welding or clamping straps cannot be used where there is a multiplicity of MOM junctions, such as in chains or twisted cable, or where dissimilar metals are involved. Additionally, the use of non-conductive materials or conductive straps is very expensive. To overcome these limitations while effectively reducing IMI, an inexpensive method that maintains the structural integrity of supporting hardware while providing a highly conductive current path is required. The chemical composition of the present invention used to overcome IMI contains compounds similar to rust removal compositions which have incorporated the general principles of chelating the ferric ion, incorporating the ion into a polymer material, and removing the rust with one polymer material. GRA

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## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-10146*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FILAMENT WINDING - WAKING THE SLEEPING GIANT**
W. T. FREEMAN, JR. and B. A. STEIN (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1985, p. 44-46, 48, 49.

The use of filament winding (FW) in the production of aerospace composite structures is examined. The FW process applies spools of fiber and prepreg tow or prepreg tape to a male mandrel; the process is more efficient and cost effective than metallic construction. The fibers used in FW and the curing process are explained. The reduced storage and fabrication costs that result from FW are discussed. The use of FW to produce a filament-wound case for a solid rocket motor and the substructure and skin of an aircraft fuselage are described. Areas which require further development in order to expand the use of FW are listed and discussed. I.F.

**A86-10267**

### COMPUTATIONAL FLUID DYNAMICS - ITS PRESENT STATUS AND FUTURE DIRECTION

E. KRAUSE (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) Computers and Fluids (ISSN 0045-7930), vol. 13, no. 3, 1985, p. 239-269. DFG-supported research. refs

Developments and advances in numerical fluid dynamics are being reviewed with emphasis on physical aspects in preference to methodical questions. The governing equations of fluid dynamics, describing the conservation of mass, momentum, and energy are discussed first. Recent work on predictions of inviscid, and of boundary-layer flows is then described in the following two sections. Thereafter, computations of fully viscous flows by numerical solutions of the Navier-Stokes equations are elucidated with several examples of the recent literature. Author

**A86-10372**

### THE DEVELOPMENT OF A VERTICAL GYROSCOPE FOR REMOTELY PILOTED VEHICLE (RPV) APPLICATIONS

D. W. ALFORD (Ferranti Instrumentation, Ltd., Bracknell, England) IN: Remotely piloted vehicles; International Conference, 4th, Bristol, England, April 9-11, 1984, Proceedings . Bristol, University of Bristol, 1984, p. 26.1-26.18. Research supported by the Ministry of Defence (Procurement Executive).

The development of gyroscope technology over the last forty years is reviewed with emphasis given to air-powered gyroscopes; hermetically sealed gyroscopes; and electrically powered attitude indicators. Some design improvements incorporated into the Type FS60A Vertical Gyroscope for RPV applications are considered. The gyroscope design consists of a motor stator, two gyro wheel halves, and the top and bottom gyro wheel housings. The stator is wound to accept the output of a 400-Hz three-phase static inverter. The outer gimbal axis is mounted vertical to the azimuthal axis, and azimuthal position are measured using a sine/cosine potentiometer. The angular momentum of the gyro is 11,000,000 g per sq cm, and the rotor speed is 22,500 r/min nominal. The gyro pendulum error loci for turning flight are shown in a line drawing. I.H.

**A86-10476#**

### CORRECTION OF LIFT COEFFICIENT FOR TANDEM CIRCULAR-CASCADE DIFFUSERS

H. HAYAMI, Y. SENOO (Kyushu University, Fukuoka, Japan), and F. KITAYAMA JSME, Bulletin (ISSN 0021-3764), vol. 28, July 1985, p. 1354-1358. refs

The interaction between two rows of cascades is discussed quantitatively. The lift characteristics of each cascade of a tandem cascade are calculated numerically based on a two-dimensional potential theory, and the result is compared with the lift characteristics of the individual cascades without mutual interaction; then, the correction factors due to mutual interaction are obtained. The performance of a low-solidity circular tandem-cascade diffuser is predicted using those correction factors and compared with experimental results. The blade circulation of each cascade is also evaluated from the measured pressure distribution along the blade surface and compared with the prediction. C.D.

**A86-10481#**

### PREDICTION OF OUTLET FLOW CHARACTERISTICS OF CENTRIFUGAL IMPELLERS. I - CONSIDERATION OF VELOCITY DISTORTION

J. KUROKAWA (Yokohama National University, Japan) and S. HODE (Mitsubishi Heavy Industries Co., Ltd., Kobe, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, July 1985, p. 1423-1429. refs

An analytical method for predicting the outlet flow characteristics from a centrifugal impeller is proposed. The method takes hub-to-shroud and blade-to-blade velocity distortion into consideration, and its usefulness is confirmed by measurements with pump impellers. It is concluded that, in calculating the theoretical head coefficient and the slip factor from the measured velocity of the absolute flow at the impeller outlet, the mass-averaged velocity of the section should be used. To get satisfactory prediction of the outlet flow characteristics, the increment of the wall shearing stress near the inlet of the parallel-walled diffuser channel due to the nonuniform flow must be considered. The influence of velocity distortion in the hub-to-shroud direction should be considered when the parallel-walled diffuser width is larger than the impeller exit width. C.D.

**A86-10620#**

### APPLICATION OF THE LOCAL STRAIN METHOD TO FATIGUE LIFE ESTIMATION OF A WING MAIN BEAM SPECIMEN

Y. WU, X. JIANG, S. XU, and H. LI Acta Mechanica Solida Sinica, June 1985, p. 183-194. In Chinese, with abstract in English. refs

An elastic-plastic finite element analysis is performed on a wing main beam specimen. The crack formation life of the main beam specimen is estimated based on the local strain method, and a comparison is made between different damage calculating methods with the effect of notch two axis stress and average stress taken into account. The 25-level and six level program fatigue tests are performed. The calculated results are in agreement with test results, the coefficient of scatter being three. Author

**A86-10822**

### THE LAMINAR-TURBULENT TRANSITION ZONE IN THE BOUNDARY LAYER

R. NARASIMHA (Indian Institute of Science; National Aeronautical Laboratory, Bangalore, India) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 22, no. 1, 1985, p. 29-80. Research sponsored by the Aeronautics Research and Development Board. refs

The flow during transition from the laminar to a turbulent state in a boundary layer is best described through the distribution of the intermittency. In constant-pressure, two-dimensional flow, turbulent spots appear to propagate linearly; the hypothesis of concentrated breakdown, together with Emmons's theory, leads to an adequate model for the intermittency distribution over flow regimes ranging all the way from low subsonic to hypersonic speeds. However, when the pressure gradient is not zero, or when the flow is not two-dimensional, spot propagation characteristics are more complicated. The resulting intermittency distributions often show peculiarities that may be best viewed as 'subtransitions'. Previous experimental results in such situations are reviewed and recent results and models are discussed. The problem of predicting the onset of transition remains difficult, but is outside the scope of the present article. Although this paper is intended to be chiefly a survey, several new results in various stages of publication are also included. Author

**A86-11232*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### A MATHEMATICALLY SIMPLE TURBULENCE CLOSURE MODEL FOR ATTACHED AND SEPARATED TURBULENT BOUNDARY LAYERS

D. A. JOHNSON and L. S. KING (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1684-1692. Previously cited in issue 08, p. 1079, Accession no. A84-2[illegible]854. refs

**A86-11245*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### STRUCTURAL OPTIMIZATION BY MULTILEVEL DECOMPOSITION

J. SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA), B. B. JAMES, and A. R. DOVI (Kentron International, Inc., Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 1, p. 124-143) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1775-1782. Previously cited in issue 12, p. 1737, Accession no. A83-29741. refs

**A86-11246#**

### THERMOELASTIC AND ELECTROMAGNETIC DAMPING ANALYSIS

U. LEE (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 183-191) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1783-1790. USAF-supported research. Previously cited in issue 13, p. 1914, Accession no. A84-31705. refs

**A86-11250#**

### EXTENSION OF THE BLASIUS FORCE THEOREM TO SUBSONIC SPEEDS

A. BARSONY-NAGY (Technion - Israel Institute of Technology, Haifa, Israel) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1811, 1812. Research supported by the Technion V.P.R. Fund-L. Rogow Aeronautical Research Fund. refs

The theorem considered by Blasius (1910) represents a well-known method for calculating the force on a body situated in an incompressible, inviscid two-dimensional flow. The efficiency of the Blasius theorem is due to its quality of expressing the forces with the aid of contour integrals of analytic functions of complex variables. The present note has the objective to deduce an analog of Blasius theorem for the aerodynamic forces in subsonic flow. It is assumed that an approximate velocity potential of the subsonic flow has been calculated by using the Imai-Lamla method. It is pointed out that this method is a variant specially suited for the two-dimensionally flows of the Janzen-Rayleigh expansion method. The derived formula expresses the aerodynamic forces with the aid of contour integrals of analytic complex functions. It can be regarded as the Blasius theorem with first-order compressibility correction for the subsonic speed regime. G.R.

**A86-11343#**

### MODE INTERACTION HOPF BIFURCATION IN AXISYMMETRIC SHELLS

A. MAEWAL (Yale University, New Haven, CT) IN: 1984 advances in aerospace sciences and engineering: Structures, materials, dynamics, and space station propulsion; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 135-138. refs

(Contract AF-AFOSR-82-076)

The Hopf bifurcation in axisymmetric shells is analyzed, taking into account the structural nonlinearities as well as the mode interaction between circumferentially traveling waves. Aerodynamic flutter is the most notable physical realization of Hopf bifurcation. The results obtained can form a basis for a computational algorithm for analysis of flutter of shells of revolution along the lines of the numerical schemes for nonlinear oscillations. F.J.

**A86-11344#**

### SERVO-ELASTIC OSCILLATIONS - CONTROL OF TRANSIENT DYNAMIC MOTION OF A PLATE

S. N. ATLURI (Georgia Institute of Technology, Atlanta) and P. E. ODONOGHUE IN: 1984 advances in aerospace sciences and engineering: Structures, materials, dynamics, and space station propulsion; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 139-147. refs

(Contract AF-AFOSR-84-0020)

The control of the transient dynamic response of an initially stressed flat plate representing the continuum model of a large space structure (LSS) is presented using a boundary-element approach. The discretization of the equation of motion of the plate, using a singular solution approach, the control of dynamic response, and the control spillover are discussed. The implementation of algorithms for an efficient solution of Ricatti equations is accomplished. F.J.

**A86-11416#**

### OPERATIONAL AND SUPPORT CONSIDERATIONS IN STANDARDIZATION

W. T. OREILLY (Westinghouse Defense and Electronics Center, Baltimore, MD) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 115-119.

(AIAA PAPER 85-5063)

Military applications in the era of the 1990's and beyond, require capabilities beyond those available in most existing systems. These capabilities must be provided in a manner that will achieve a low logistic support cost and that can be maintained with relatively inexperienced personnel. This paper presents the design considerations that must be addressed in each of the standardized subsystems and modules that will provide the operational and support needs for tomorrow and beyond. Advanced maintenance concepts, such as two and one level maintenance, are described together with the operational and life cycle cost benefits that will be achieved. A new operation concept called deferred maintenance, which provides sustained operation without maintenance support, is presented. The fault tolerant architecture which will permit a standardized modular design to efficiently accommodate a variety of system applications is presented. The concerns discussed include combat damage survivability, fail safe and fail operational needs, as well as high availability for long life applications as is required for systems employed in the Space Defense Initiative (SDI). Author

**A86-11457#**

### NEW DIRECTIONS IN AEROSPACE PACKAGING

J. W. KANZ (Hughes Aircraft Co., El Segundo, CA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 427-431. refs

(AIAA PAPER 85-6033)

The packaging of electronic devices for aerospace applications is discussed. Consideration is given to the problems encountered in dual-in-line packaging; surface mounting; and pin-grid-arrays. Some limitations of Leadless Chip Carrier (LLC) packages are discussed with respect to reliability; standardization; and handling and testing. I.H.

**A86-11460#**

### RADIATION HARDENED CMOS TECHNOLOGY FOR FLIGHT SYSTEMS

B. PEARSON (Harris Semiconductor, Melbourne, FL) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 449-452.

(AIAA PAPER 85-6040)

The techniques used to harden CMOS devices against the effects of radiation are examined, and the performance tradeoffs of hardened versus nonhardened devices are discussed. In particular, attention is given to the following three technologies used in the manufacture of hardened CMOS: CMOS on EPI silicon, silicon on insulator, and dielectric isolation. Finally, the hardness levels attainable with these three technologies are compared with those of bipolar devices. V.L.

**A86-11461#**

**VISION-BASED ROAD FOLLOWING FOR AN AUTONOMOUS LAND VEHICLE**

A. M. WAXMAN, J. LE MOIGNE, B. SRINIVASAN, L. S. DAVIS, and A. ROSENFELD (Maryland, University, College Park) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 453-458.

(Contract DAAK70-83-0018; DAAK76-84-C-0004; DARPA ORDER 3206; DARPA ORDER 5096)

(AIAA PAPER 85-6047)

An approach to visual navigation developed under the Autonomous Land Vehicle project is presented. The approach includes a bootstrap phase and a feed-forward phase, with visual processing in each phase executed in three modules: an image processing module, a geometry module, and a rule-based reasoning module. Process control for road following is described, with particular attention given to the image processing algorithms for the bootstrap phase. Guidelines for future work are briefly discussed. V.L.

**A86-11554**

**AIRCRAFT GAS-TURBINE ENGINES IN GROUND-BASED APPLICATIONS [AVIATSIONNYE GTD V NAZEMNYKH USTANOVKAKH]**

S. P. IZOTOV, V. V. SHASHKIN, V. M. KAPRALOV, M. G. KALASHNIKOV, O. A. RUDAKOV et al. Leningrad, Izdatel'stvo Mashinostroenie, 1984, 232 p. In Russian. refs

The general design and the principle of operation of aircraft gas-turbine engines are reviewed, and their possible ground-based applications are discussed, including surface transport, compressor plants, power-generating plants, and pumping equipment. In particular, attention is given to the reliability and service life of gas-turbine engines used in ground equipment. The discussion also covers the problem of noise abatement, environmental factors, safety engineering, and algorithms for selecting the principal parameters of ground-based gas-turbine plants. V.L.

**A86-11617#**

**OPTIMISATION OF RECESS-ACTION CONFORMAL PROFILES FOR AERO GAS-TURBINE ENGINE GEARS - A COMPUTER BASED ANALYTICAL APPROACH**

K. RAMACHANDRA, N. NAGARAJ, and R. PADMANABHAN (Gas Turbine Research Establishment, Bangalore, India) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 165-172. refs

Profile parameters of recess-action gears and the factors influencing contact stress are discussed. A single profile parameter, the tooth thickness, was optimized with respect to the ratio of the allowable contact to bending stress. It is concluded that the tooth-profile parameters can be independently optimized so that the ratio of contact to induced bending stress equals the allowable stress ratio for the type of gear material used. It is shown that, for helix angles lower than 20 deg, the thicknes of the pinion tooth can be reduced without reducing the load-carrying capacity, and the conventional thickness of the wheel tooth must be increased to make optimum use of the material strength. I.S.

**A86-11621#**

**A SIMPLE METHOD FOR EVALUATING THERMAL STABILITY OF LABYRINTH SEALS**

S. PATHAK (Hindustan Aeronautics, Ltd., Engine Design Bureau, Bangalore, India) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 191-198. refs

A relatively simple criterion is defined for a quick check of thermal stability of labyrinth seals in gas turbine engines following rub in service. In spite of its simplicity, the criterion agrees well with the results obtained from the established sophisticated program. The criterion and the defined considerations apply to both stable and unstable designs, successfully predicting either stability or instability. The parameters of influence lay down guidelines for the designer in considering configurations of stable seals. I.S.

**A86-11696#**

**EXPERIMENTAL RESULTS FROM A REVERSE FLOW ANNUAL COMBUSTOR**

F. M. JOUBERT and H. V. HATTINGH (Stellenbosch, University, Republic of South Africa) IN: International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings . New York, AIAA, 1985, p. 787-793. refs

Computer-predicted temperature distributions in the wall liners of a combustion chamber were compared to the experimentally obtained values from combustion tests carried out in a small, full-scale reverse-flow annular combustor at sea level take-off conditionns. The largest discrepancies between the measured and predicted linear temperatures occured in the primary zone, with most of the predictions falling above the measured values, and with neither of the two computer programs satisfying the accuracy of 4 percent (of the experimental values) needed for making estimates on the life of a combustor. On the other hand, the correlation between the measured and predicted liner pressure drop was satisfactory. The validity and usefulnes of simple computer models as aids in the design of gas turbine combustion chambers are discussed. I.S.

**A86-11755**

**ON FLAW SIZE AND DISTRIBUTION IN LAP JOINTS**

C. L. CHOW and C. W. WOO (University of Hong Kong, Hong Kong) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 4, Aug. 1985, p. 75-82. refs

The effect of internal flaw size and its distribution along the adhesive layer on the fracture behavior of an adhesive-bonded lap joint is investigated; adhesive lap joints are often used in both aircraft and aerospace applications. The finite element method is used to examine the localized shear stress distribution developed in the lap joint with or without bonding flaws. It is found that the shear stress distribution for adhesive joints without internal defects resembles that of an 'ideal' lap model with high stress concentrations at the lap ends and relatively low stresses over the major central portion of the lap length. It is also found that a central internal lap flaw has little effect on the overall stress distribution. However, an internal flaw close to the lap end increases the maximum shear stress. In addition, adhesively bonded aluminum specimens are analyzed, noting their fracture strength reduction when an internal flaw is present. F.J.

**A86-11774**

**THE INFLUENCE OF THICKNESS IN PREDICTIONS OF LIFETIME AND CRACK PROPAGATION IN CASES INVOLVING DYNAMICALLY LOADED AERONAUTICAL METAL SHEETS [DICKENEINFLUSS BEI DER LEBENSDAUER- UND RISSFORTSCHRITTSVORHERSAGE DYNAMISCH BEANSPRUCHTER LUFTFAHRTBLECHE]**

P. MAKRIS and K. STEIN (Athens, National Technical University, Greece) Materialpruefung (ISSN 0025-5300), vol. 27, Aug. 1985, p. 228-233. In German. Research supported by the Aluminium Hellas. refs

Makris and Stein (1984) have discussed a procedure for predicting crack propagation and lifetime in the case of metal sheets used in aircraft construction, taking into account dynamic stresses on the basis of engineering model concepts. The present paper is concerned with the effect of the thickness of the specimens on their lifetime. The reported investigation includes an evaluation of experiments which have been conducted with specimens consisting of the material AlCuMg2. The mechanisms involved in the effects produced by differences in specimen thickness are examined, giving attention to statistical size effects, stress-mechanical size effects, technological size effects, and fracture-mechanics thickness effects. Possibilities for taking into account thickness effects in a lifetime prediction based on the model considered by Makris and Stein are also discussed. G.R.

**A86-11937*#** Arizona State Univ., Tempe.

### CONCENTRATION DISTRIBUTIONS IN CYLINDRICAL COMBUSTORS

S. A. AHMED and R. M. C. SO (Arizona State University, Tempe) IN: Experimental measurements and techniques in turbulent reactive and non-reactive flows; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 91-106. refs
(Contract NAG3-260)

Experimental studies have been conducted with the aim to obtain a better understanding of the fluid dynamics of mixing in gas turbine combustors, and solid fuel ramjet combustors subject to spin. The present investigation represents a continuation of studies conducted by So et al. (1984). It is also concerned with the verification of some conclusions reported by Ahmed et al. (1984). Attention is given to the experimental facility and instrumentation, centerline concentration measurements, mean concentration profiles, and a comparison of concentration and axial velocity results in the case of swirling flow. G.R.

**A86-11938*#** United Technologies Research Center, East Hartford, Conn.

### SCALAR AND MOMENTUM TURBULENT TRANSPORT EXPERIMENTS WITH SWIRLING AND NONSWIRLING FLOWS

B. V. JOHNSON, R. ROBACK (United Technologies Research Center, East Hartford, CT), and J. C. BENNETT (Connecticut, University, Storrs) IN: Experimental measurements and techniques in turbulent reactive and non-reactive flows; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 107-119. refs
(Contract NAS3-22771)

Combustor models for the aircraft gas turbine industry have been obtained because of the need to reduce the costs of developing improved performance and more durable engines. A few years ago, it became apparent that the mass concentration and velocity predictions provided by the computer codes were not representing the data measured in some confined recirculating flows. It is pointed out that errors in the mass concentration distribution are an especially serious problem because of their influence on the heat release, temperature, and reactant distributions. Combined mass and momentum turbulent transport experiments with swirling and nonswirling flow have been conducted with the objective to obtain an experimental data base which can be used to evaluate and improve the turbulent transport submodes employed in the aerothermal models. The present paper is mainly concerned with the overall characteristics of the mass turbulent transport processes in complex flows with recirculation and the deficiencies of the conventional models. G.R.

**A86-12074**

### AN OVERVIEW OF EMP EFFECTS AND THEIR CONTROL

A. J. CULLIGAN (Plessey Assessment Services, Ltd., England) (Society of Environmental Engineers, International Symposium on Product Design Assurance in Engineering, Wembley, England, June 11-13, 1985) Society of Environmental Engineers, Journal (ISSN 0374-356X), vol. 24-3, Sept. 1985, p. 9-11. refs

The environments associated with a nuclear detonation are probably the most extreme of all the environments to which an electronic equipment system may be exposed. One of these environments is related to the electromagnetic pulse (EMP) which represents an intense pulse of radiated electromagnetic energy. The endo-atmospheric EMP is generally not considered a major threat in comparison with other nuclear weapon effects related to blast, thermal phenomena, neutrons, and gamma rays. The situation is different with respect to the exo-atmospheric EMP which has the potential to simultaneously damage communication and allied networks over many thousands of square miles. The present paper is concerned with these EMP effects and the possibilities for protecting equipment from EMP. For such a protection, an understanding of the system's electronic topology is essential, and component/circuit susceptibility levels must be specified. Attention is given to the wire grid model of a strike aircraft, and the simulation of the EMP environment. G.R.

**A86-12272#**

### AERODYNAMIC RESISTANCE OF PERFORATED PLATES IN NATURAL CONVECTION

M. ISHIZUKA, Y. MIYAZAKI, and T. SASAKI (Toshiba Corp., Research and Development Center, Kawasaki, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1697-1702.

This paper describes some experimental results about aerodynamic resistance of perforated plates in natural convection, which are useful for designing casings of electronic equipment. Since velocity through a perforated plate and pressure loss are very small in the case of natural convection, the conventional method can not be used to measure the resistance of the plate with reasonable accuracy. Therefore, a new method was developed to obtain resistance coefficients of plates by temperature measurement, since differential temperature between the upstream flow of a perforated plate and the downstream one is related to its aerodynamic resistance. Using the proposed method, further experiments were performed to study the influence of various parameters, such as Reynolds number, porosity coefficient, and plate thickness/hole diameter on resistance coefficients of perforated plates. Author

**A86-12276#**

### A MEASUREMENT METHOD TO EVALUATE FLUID FORCE ON BLADES

H. ISHII and N. HAGIWARA (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Tsuchiura, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Aug. 1985, p. 1741-1748. refs

The purpose of this study is to establish a measurement method for the fluid force acting on axial turbo machines. The method aims to evaluate the fluid forces as divided into two components, i.e., exciting force and damping force. This method is found to be satisfactory in comparison with other ordinary methods of estimating the fluid force acting on a column test piece in a wind tunnel. According to the results of a test using an axial compressor model with flat blades, the method can quantitatively predict the fluid force acting on rotating blades. Moreover, it is applicable to actual machines. Author

**A86-12528**

### FLUTTER ANALYSIS OF A THIN-WALLED LIFTING SURFACE [RASCHET NA FLATTER TONKOSTENNOI NESUSHCHEI POVERKHNOSTI]

M. B. VAKHITOV, A. S. SAFONOV, and I. A. KUZNETSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 11-14. In Russian.

A numerical method is proposed for the flutter analysis of thin-walled lifting surfaces, such as an aircraft wing. The method is based on Odinokov's (1948) theory in which differential equations are solved using integrating matrices. Aerodynamic loads acting on the wing are calculated using the discrete vortex method. Results are presented for a model structure. V.L.

**A86-12536**

### AN ASSESSMENT OF THE EFFECT OF CORROSION WEAR ON THE STRESSED STATE AND DURABILITY OF PLATES AND SHELLS [OTSENKA VLIIANIIA KORROZIONNOGO IZNOSA NA NAPRIAZHENNOE SOSTOIANIE I DOLGOVECHNOST' PLASTINOK I OBOLOCHEK]

I. G. OVCHINNIKOV and KH. A. SABITOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1985, p. 42-45. In Russian. refs

Methods for including the effect of corrosion wear in the analysis of nonlinear elastic plates and shells are examined with particular reference to the method of consecutive parameter perturbations. The effect of material nonlinearity on the deformation behavior of a corroding plate is discussed. An analysis is also made of the effect of material nonlinearity on the durability of a cylindrical shell. V.L.

**A86-12561**

### AE MONITORING OF JET ENGINE BREECH CHAMBERS

N. DHOND and D. M. EGLE (Oklahoma, University, Norman) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S30, S31. refs

It is pointed out that a breech chamber is an important component of the emergency or quick starting mechanism in jet engines. The hot gases produced from a rapidly burning cartridge drives a turbine which rotates the engine. Premature failures in these chambers, which may occur occasionally, can have serious consequences. It is believed that one of the causes of failure is related to stress corrosion cracking (SCC). For this reason, an investigation was conducted concerning the possibility to use acoustic emission (AE) as a means of detecting the presence of SCC and/or participating critical flaws. A commercially available AE system was used to monitor the chambers. Aspects of AE activity in breech chambers are discussed, and approaches for distinguishing a growing crack from other sources of AE are considered. G.R.

**A86-12562**

### ACOUSTIC EMISSION STUDIES FOR DETECTION AND MONITORING INCIPIENT CRACKS IN A SIMULATED AERO ENGINE MOUNT UNDER FATIGUE

S. C. PATHAK and C. R. L. MURTHY (Indian Institute of Science, Bangalore, India) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S32-S34. Research supported by the Aeronautical Research and Development Board.

Fatigue crack growth in critical structural members affects safety, operational availability, and maintenance of an aircraft. A long felt need exists, therefore, for a procedure involving the remote detection and monitoring of incipient fatigue cracks in critical aircraft structures. A dynamic nondestructive testing (NDT) technique which continuously monitors critical assemblies is required, taking into account early warning before the cracks reach limits of criticality. Acoustic emission (AE) appears to be most suited for this application. However, the AE technique requires further development for the considered employment. The present investigation represents the first step in such a development. An attempt is made to develop a criterion for establishing correlation between true AE data and crack initiation and growth in the presence of typical noise sources. G.R.

**A86-12573**

### IN-FLIGHT AE MONITORING

G. G. MARTIN and I. G. SCOTT (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S142-S146. refs

In August 1978, acoustic emission (AE) monitoring equipment was installed in a Royal Australian Air Force Macchi jet trainer aircraft to assess the feasibility of using AE for in-flight monitoring of crack growth. Aircraft of the considered type are flown under a safety-by-inspection procedure involving the monitoring of growing fatigue cracks in the center-section assembly tension spar with the aid of a magnetic rubber inspection (MRI) technique. Attention is given to the employed AE monitoring system, the test program, and a discussion of the test results. These results establish the feasibility of monitoring crack growth, during flight of a jet trainer aircraft. However, further work is needed before AE sources can be identified. G.R.

**A86-12575**

### ACOUSTIC EMISSION MONITORING OF AIRCRAFT STRUCTURES

S. L. MCBRIDE (Royal Military College of Canada, Kingston) and J. W. MACLACHLAN (Johns Hopkins University, Baltimore, MD) Journal of Acoustic Emission, Supplement (ISSN 0730-0050), vol. 4, Apr.-Sept. 1985, p. S151-S154. Research supported by the Defence Research Establishment Pacific. refs

Since the mid-1970s, several studies have explored the feasibility of using acoustic emission to monitor the integrity of aircraft structural components. This paper provides a summary of the principal findings of the program of the Canadian Department of National Defence in this area. In phase I of this program, a single-channel recording system was used to record data in-flight from a wing attachment component on the CF100 jet interceptor aircraft during a period of about a year. It was found that the transient burst signals detected varied over at least two orders of magnitude in amplitude and in number of events per flying hour. In phase II, a dual-channel recording system was employed to record simultaneously data from two symmetrically located wing attachments, while in phase III, a precracked laboratory test specimen was mounted in a structure across the inner fuselage of a CC130 aircraft. G.R.

**A86-12600**

### RELIABILITY OF WIDE-BODY AIRCRAFT [NADEZHNOST' SHIROKOFIUZELIAZHNYKH SAMOLETOV]

G. V. NOVOZHILOV Akademiia Nauk SSSR, Vestnik (ISSN 0002-3442), no. 8, 1985, p. 93-101. In Russian.

The use of a systems approach in assuring the reliability and flight safety of commercial wide-body aircraft is discussed with particular reference to the Il-86 and Il-96 aircraft. The role of computer-aided design is emphasized, and specific steps taken at each stage of aircraft design and testing to assure the reliability of the individual components and of the aircraft as a whole are discussed. Particular attention is given to the use of finite elements in displacements for the strength analysis of aircraft structures. V.L.

**A86-12608**

### TURBULENCE CHARACTERISTICS OF A PLANE DIFFUSER FLOW WITH INLET VELOCITY DISTORTION

P. A. ASWATHA NARAYANA, N. V. CHANDRASEKHARA (Indian Institute of Technology, Madras, India), and V. K. CHITHAMBARAN Indian Institute of Science, Journal, Section A - Engineering and Technology (ISSN 0019-4964), vol. 65, April 1984, p. 57-70. refs

An experimental study of turbulent characteristics of incompressible flow in a two-dimensional diffuser with inlet velocity distortion is reported. Turbulence level in the boundary layer increases marginally towards the exit of the diffuser and decreases rapidly in the wake region. The region of maximum velocity fluctuation and the maximum Reynolds shear stress shifts away from the wall in the streamwise direction. The energy spectra of the turbulent kinetic energy in the wake region shows a characteristic behaviour indicating possible vortex shedding from the trailing edge of the airfoil. Author

**N86-10550** Westland Helicopters Ltd., Yeovil (England).

### TRIALS ON THE ASPERITY COUNTING MONITORING SYSTEM Final Report

R. WORDSWORTH (Imperial Coll. of Science and Technology) and P. B. MACPHERSON May 1984 32 p refs
(Contract A12/1347)
(RES-PAPER-670; BR93962) Avail: Issuing Activity

A monitoring system, based on asperity contacts within a loaded and lubricated pair of metal surfaces, was evaluated in a mini disk machine. Results confirm the sensitivity of the system to changes in surface topography. With additional storage capacity available in microcomputers, a tool for laboratory test running normally undertaken in a mechanical research laboratory is available. The monitor could also be applied in a gearbox test rig for studying the performance of a specific bearing or gear set.

Although interest in grease as a gearbox lubricant waned an effective system for routine monitoring of helicopter tail and intermediate gearboxes is feasible. Author (ESA)

**N86-10554#** Department of the Navy, Washington, D. C.
**AIRBOC (AIR RAPID BLOOM OFFBOARD CHAFF) CHAFF DEPLOYMENT SYSTEM Patent Application**
W. HUMPHRIES, J. BRYANT, R. C. EKLUND, D. C. HAYES, and P. FERKO, inventors (to Navy) 1 Apr. 1985 14 p
(AD-D011746; US-PATENT-APPL-SN-718399) Avail: NTIS HC A02/MF A01 CSCL 17D

An AIRBOC (Air Rapid Bloom Offboard Chaff) chaff deployment apparatus comprising a canister with a wind flap attached externally to the canister and connected to a drogue chute that is housed inside the canister. The drogue chute is situated atop a main chute that is atop a release mechanism, which is atop a fuze and that is atop a chaff payload, all of which is housed inside the canister. When the AIRBOC is dropped from a plane, the wind flap extends, pulling out the drogue chute. The drogue chute in turn activates the release mechanism which frees the drogue chute to pull out the main chute to which the drogue chute is connected. The deployment of the main chute causes a force greater than 40 lbs to be applied to the release mechanism, resulting in the chaff payload being released from the canister and the fuze being activated, consequently detonating the released chaff payload. GRA

**N86-10564#** Societe Nationale Industrielle Aerospatiale, Suresnes (France). Lab. Central.
**NONDESTRUCTIVE CONTROL OF THICK STRUCTURES MADE WITHOUT DISASSEMBLING [CONTROLE NON DESTRUCTIF D'ASSEMBLAGE DE FORTES EPAISSEURS SANS DEMONTAGE DES FIXATIONS, PROCES VERBAL 43-954/F/3]**
D. LECURU 21 Jan. 1985 43 p refs In FRENCH
(Contract STPA-82-96-006)
(PV-43-954/F/3) Avail: NTIS HC A03/MF A01

Ultrasonic and Foucault current methods to inspect aircraft structures in places were plate superposition gives a total thickness 5 to 7 mm were studied. The feasibility of the ultrasonic is demonstrated for external plates, while that of the Foucault current method is shown for the inner plates up to 20 mm thickness. Author (ESA)

**N86-10581*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FATIGUE OF GRAPHITE/EPOXY BUFFER STRIP PANELS WITH CENTER CRACKS**
C. A. BIGELOW Aug. 1985 32 p refs
(NASA-TM-87595; NAS 1.15:87595) Avail: NTIS HC A03/MF A01 CSCL 20K

The effects of fatigue loading on the behavior of graphite/epoxy panels with either S-Glass or Kevlar-49 buffer strips is studied. Buffer strip panels are fatigued and tested in tension to measure their residual strength with crack-like damage. Panels are made with 45/0/-45/90 sub 2s layup with either S-Glass or Kevlar-49 buffer strip material. The buffer strips are parallel to the loading direction and made by replacing narrow strips of the 0-degree graphite plies with strips of either 0-degree S-Glass/epoxy or Kevlar-49/epoxy on a one-for-one basis. The panels are subjected to a fatigue loading spectrum MINITWIST, the shortened version of the standardized load program for the wing lower surface of a transport aircraft. Two levels of maximum strain are used in the spectrum with three durations of the fatigue spectrum. One group of panels is preloaded prior to the application of the fatigue cycling. The preload consists of statistically loading the spectrum in tension until the crack-tip damage zone reaches the ajacent buffer strips. After fatigue loading, all specimens are statistically loaded in tension to failure to determine their residual strengths. Author

**N86-10594#** Societe Nationale Industrielle Aerospatiale, Suresnes (France). Lab. Central.
**NONDESTRUCTIVE CORROSION TEST OF ALUMINUM ALLOY STRUCTURES [CONTROLE NON DESTRUCTIF DE LA CORROSION DANS LES ASSEMBLAGES EN ALLIAGES D'ALUMINIUM, PROCES VERBAL PV 43-954/F2]**
D. LECURU 21 Jan. 1985 63 p refs In FRENCH
(Contract STPA-82-96006)
(PV-43-954/F/2) Avail: NTIS HC A04/MF A01

In order to avoid maintenance cost penalties, aluminum aircraft structure nondestructive test methods are studied, including ultrasonics, radiography, neutronography and Foucault currents. The results show that pitting corrosion is easy to detect, but intergranular corrosion is better detected by ultrasonics or neutronography. The best solution to inspect real aircraft structures is a method based on multiparameter analysis of ultrasonic signals. Author (ESA)

**N86-11228*#** LTV Aerospace and Defense Co., Dallas, Tex. Vought Aero Products Div.
**THE FACTORY OF THE FUTURE**
J. E. BYMAN *In* NASA. Langley Research Center Welding, Bonding and Fastening, 1984 p 1-9 Sep. 1985
Avail: NTIS HC A21/MF A01 CSCL 13H

A brief history of aircraft production techniques is given. A flexible machining cell is then described. It is a computer controlled system capable of performing 4-axis machining part cleaning, dimensional inspection and materials handling functions in an unmanned environment. The cell was designed to: allow processing of similar and dissimilar parts in random order without disrupting production; allow serial (one-shipset-at-a-time) manufacturing; reduce work-in-process inventory; maximize machine utilization through remote set-up; maximize throughput and minimize labor. R.J.F.

**N86-11233*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THE ALTERNATING SURFACE SEGMENTED LAP JOINT: A DESIGN FOR THIN HIGHLY LOADED JOINTS**
V. E. WATKINS, JR. and G. C. FIRTH *In its* Welding, Bonding and Fastening, 1984 p 67-76 Sep. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 13E

The combination of thin airfoil sections and high aerodynamic loads on many wind tunnel models presents a major problem for attachment of flap elements. Conventional methods of attaching fixed control elements such as lap and tongue-in-groove joints are not rigid enough to provide surface continuity required in high Reynolds number research. For the extreme cases, the solution has been to fabricate separate wings for each flap setting with the flap element being and integral part of the wing. Here an attractive solution to this problem, the alternating surface segmented lap joint, is discussed. This joint provides increased rigidity and lower stress levels than conventional joints. Additionally, attachment fastener loading is low and the joint can be designed to accommodate high shear levels due to bending without the use of dowel pins. Author

**N86-11247*#** Douglas Aircraft Co., Inc., Long Beach, Calif.
**ADVANCES IN JOINING TECHNIQUES USED IN DEVELOPMENT OF SPF/DB TITANIUM SANDWICH REINFORCED WITH METAL MATRICES**
J. E. FISCHLER *In* NASA. Langley Research Center Welding, Bonding and Fastening, 1984 p 297-322 Sep. 1985
Avail: NTIS HC A21/MF A01 CSCL 13M

Three and four-sheet expanded titanium sandwich sheets have been developed at Douglas Aircraft Company, a division of McDonnell Douglas Corporation, under contract to NASA Langley Research Center. In these contracts, spot welding and roll seam welding are used to join the core sheets. These core sheets are expanded to the face sheets and diffusion bonded to form various type cells. The advantages of various cell shapes and the design parameters for optimizing the wing and fuselage concepts are discussed versus the complexity of the spot weld pattern. In addition, metal matrix composites of fibers in an aluminum matrix encapsulated in a titanium sheath are aluminum brazed successfully to the titanium sandwich face sheets. The strength and crack growth rate of the superplastic-formed/diffusion bonded (SPF/DB) titanium sandwich with and without the metal matrix composites are described. Author

**N86-11362#** New Mexico Univ., Albuquerque. Engineering Research Inst.
**VALIDATION OF PROCEDURES FOR PAVEMENT DESIGN ON EXPANSIVE SOILS Final Report, May 1984 - Aug. 1985**
R. G. MCKEEN Washington FAA Jul. 1985 99 p refs
(Contract F29601-84-C-0080)
(FAA-PM-85-15; NMERI-WA5-4(5.02)) Avail: NTIS HC A05/MF A01

This report documents site investigations and design recommendations for airport pavements on expansive soils at three sites. The methods used were developed previously in an FAA-sponsored research project. The design procedure involves soil characterization, determination of surface characteristics and evaluation of soil-pavement interaction. Investigations at three airports are reported; they are Murdo, South Dakota, Mesquite, Texas, and Love Field, Dallas, Texas. Soils data are used along with climatic information to obtain estimates of the equivalent thickness of pavement required for each site. The work at Love Field was somewhat different than the other sites since NMERI was not directly conducting the investigation. Results are reported in the form of pavement thickness required to adequately perform, in terms of surface roughness, on the soil surface characteristics predicted for each site. Recommendations are included for consideration in rehabilitation of each site since all were experiencing surface roughness at the time of the investigations. These results confirm that methods developed for evaluating airport pavements on expansive soils provide useful information for pavement design. B.W.

**N86-11430#** Naval Ship Research and Development Center, Bethesda, Md.
**APPLICATION OF THE VORTEX-LATTICE CONCEPT TO FLOWS WITH SMOOTH-SURFACE SEPARATION Final Report**
D. F. THRASHER Jul. 1985 69 p
(AD-A157571; DTNSRDC-85/041) Avail: NTIS HC A04/MF A01 CSCL 20D

Numerical schemes based on the vortex-lattice concept have had considerable success in treating the fully three-dimensional separated potential flow over low aspect-ratio thin wings at high incidence and the attached potential flow over bodies of more general shape. In principle, the vortex-lattice method is not limited in application as long as convection dominates vorticity diffusion. A non-linear 3-D vortex-lattice method was developed which treats the steady separated flow over prolate bodies with open separation moving through an inviscid incompressible fluid. The strength and position of the body wake were found as part of the solution. Flows with smooth-surface separation were considered as opposed to flows with sharp-edge separation treated with the vortex-lattice concept in the past. Results for flow over an inclined ogive-cylinder demonstrated the technique. For attached flow, comparisons are presented of the results from the vortex-lattice method using optimal and average control point locations with the results of the source-distribution method and with experimental data. The same panel arrangement was used calculating both methods. The results of the present method are somewhat more sensitive to panel arrangement than are those for the source-distribution method. Also, the effect of control point location varies dramatically as the incidence of the body is changed. For separated flow, results of the vortex-lattice method were compared with experimental data and with the results of a typical 2-D analogy. The present method agrees favorably with the experimental data windward of a separation line. GRA

**N86-11495*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**TURBINE ENGINE HOT SECTION TECHNOLOGY (HOST)**
Oct. 1983 250 p refs Workshop held in Cleveland, Ohio, 25-26 Oct. 1983
(NASA-CP-2289; E-1816; NAS 1.55:2289) Avail: NTIS HC A11/MF A01 CSCL 21E

A two-day workshop on the research and plans for turbine engine hot section durability problems was held on October 25 and 26, 1983, at the NASA Lewis Research Center. Presentations were made during six sessions, including structural analysis, fatigue and fracture, surface protective coatings, combustion, turbine heat transfer, and instrumentation, that dealt with the thermal and fluid environment around liners, blades, and vanes, and with material coatings, constitutive behavior, stress-strain response, and life prediction methods for the three components. The principal objective of each session was to disseminate the research results to date, along with future plans, in each of the six areas. Contract and government researchers presented results of their work.

**N86-11496*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**TURBINE ENGINE HOT SECTION TECHNOLOGY (HOST) PROJECT**
D. E. SOKOLOWSKI and C. R. ENSIGN *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 1-6 Oct. 1983
Avail: NTIS HC A11/MF A01 CSCL 21E

The Hot Section Technology (HOST) Project is a NASA-sponsored endeavor to improve the durability of advanced gas turbine engines for commercial and military aircraft. Through improvements in the analytical models and life prediction systems, designs for future hot section components , the combustor and turbine, will be more accurately analyzed and will incorporate features required for longer life in the more hostile operating environment of high performance engines. G.L.C.

**N86-11497*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**HOST INSTRUMENTATION R AND D PROGRAM OVERVIEW**
D. R. ENGLUND *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 7-9 Oct. 1983
Avail: NTIS HC A11/MF A01 CSCL 14B

The HOST Instrumentation R&D program is focused on two categories of instrumentation. One category is that required to characterize the environment imposed on the hot section components of turbine engines. This category includes instruments for measuring gas flow, gas temperature, and heat flux. The second category is that for measuring the effect of the environment on the hot section components. This category includes strain measuring instruments and an optical system for viewing the interior of an operating combustor to detect cracks, buckling, carbon buildup, etc. G.L.C.

**N86-11498*#** United Technologies Research Center, East Hartford, Conn.
**HOT SECTION VIEWING SYSTEM**
W. W. MOREY *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 11-16 Oct. 1983
Avail: NTIS HC A11/MF A01 CSCL 14B

The objective of the hot section viewing program is to develop a prototype optical system for viewing the interior of a gas turbine combustor during high temperature, high pressure operation in order to produce a visual record of some causes of premature hot section failures. The program began by identifying and analyzing system designs that would provide clearest images while being able to survive the hostile environment inside the combustion chamber. Different illumination methods and computer techniques for image enhancement and analysis were examined during a preliminary test phase. In the final phase of the program the prototype system was designed and fabricated and is currently being tested on a high pressure combustor rig. G.L.C.

**N86-11499*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.

**DYNAMIC GAS TEMPERATURE MEASUREMENT SYSTEM**

D. L. ELMORE, W. W. ROBINSON, and W. B. WATKINS *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 17-35 Oct. 1983 refs
(Contract NAS3-23154)
Avail: NTIS HC A11/MF A01 CSCL 14B

A gas temperature measurement system with compensated frequency response of 1 KHz and capability to operate in the exhaust of a gas turbine combustor was developed. Environmental guidelines for this measurement are presented, followed by a preliminary design of the selected measurement method. Transient thermal conduction effects were identified as important; a preliminary finite-element conduction model quantified the errors expected by neglecting conduction. A compensation method was developed to account for effects of conduction and convection. This method was verified in analog electrical simulations, and used to compensate dynamic temperature data from a laboratory combustor and a gas turbine engine. Detailed data compensations are presented. Analysis of error sources in the method were done to derive confidence levels for the compensated data. G.L.C.

**N86-11500*#** United Technologies Research Center, East Hartford, Conn.

**HIGH TEMPERATURE STATIC STRAIN SENSOR DEVELOPMENT PROGRAM**

C. HULSE, R. BAILEY, and H. GRANT (Pratt and Whitney Aircraft Group, East Hartford, Conn.) *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 37-40 Oct. 1983
(Contract NAS3-23722)
Avail: NTIS HC A11/MF A01 CSCL 14B

Electrical resistance strain gages useful for static strain measurements on nickel or cobalt superalloy parts inside a gas turbine engine on a test stand are being developed. Measurements of this type are of great importance in meeting the goals of the HOST program because, without reliable knowledge of the stresses and strains which exist in specific components, it will be difficult to fully appreciate where improvements in design and materials can be implemented. The first part of the effort consisted of a strain gage alloy development program which will be followed by an investigation of complete strain gage systems which will use the best of the alloys developed together with other system improvements. G.L.C.

**N86-11501*#** United Technologies Research Center, East Hartford, Conn.

**DEMONSTRATION TEST OF BURNER LINER STRAIN MEASUREMENT SYSTEMS: INTERIM RESULTS**

K. A. STETSON and H. P. GRANT (Pratt and Whitney Aircraft, East Hartford, Conn.) *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 41-44 Oct. 1983
(Contract NAS3-23690)
Avail: NTIS HC A11/MF A01 CSCL 20K

Work is in progress to demonstrate two techniques for static strain measurements on a jet engine burner liner. Measurements are being made with a set of resistance strain gages made from Kanthal A-1 wire and via heterodyne speckle photogrammetry. The background of the program is presented along with current results. Author

**N86-11502*#** Pratt and Whitney Aircraft Group, East Hartford, Conn. Engineering Div.

**DEVELOPMENT OF HEAT FLUX SENSORS FOR TURBINE AIRFOILS AND COMBUSTOR LINERS**

W. H. ATKINSON *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 45-55 Oct. 1983 refs
Avail: NTIS HC A11/MF A01 CSCL 14B

The design of durable turbine airfoils that use a minimum amount of cooling air requires knowledge of the heat loads on the airfoils during engine operation. Measurement of these heat loads will permit the verification or modification of the analytical models used in the design process and will improve the ability to predict and confirm the thermal performance of turbine airfoil designs. Heat flux sensors for turbine blades and vanes must be compatible with the cast nickel-base and cobalt-base materials used in their fabrication and will need to operate in a hostile environment with regard to temperature, pressure and thermal cycling. There is also a need to miniaturize the sensors to obtain measurements without perturbing the heat flows that are to be measured. G.L.C.

**N86-11505*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**TURBINE HEAT TRANSFER**

J. E. ROHDE *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 73-77 Oct. 1983
Avail: NTIS HC A11/MF A01 CSCL 20D

Improved turbine durability and performance and reduced development cost will all result from impoved methods of predicting turbine metal temperatures. Better metal temperature prediction methods require improvements in the methods of predicting the hot gas flow over the turbine airfoils and the cooling air flow inside the airfoil and in the methods of predicting the heat transfer rates on both the hot gas side and coolant side of the airfoil. The overall HOST Turbine Heat Transfer effort is directed at improving all four of these areas of concern. G.L.C.

**N86-11507*#** Detroit Diesel Allison, Mich.

**GAS SIDE HEAT TRANSFER**

L. D. HYLTON *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 87-99 Oct. 1983 refs
(Contract NAS3-22761; NAS3-23695)
Avail: NTIS HC A11/MF A01 CSCL 20D

Improvements in methods for predicting heat transfer rates on the hot gas side of turbine airfoils are necessary for improved turbine durability and performance. The development and verification of improved analytical models requires a systematic, closely coupled experimental and analytical program. G.L.C.

**N86-11508*#** United Technologies Research Center, East Hartford, Conn.

**ASSESSMENT OF A 3-D BOUNDARY LAYER CODE TO PREDICT HEAT TRANSFER AND FLOW LOSSES IN A TURBINE**

V. N. VATSA *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 101-106 Oct. 1983 refs
(Contract NAS3-23716)
Avail: NTIS HC A11/MF A01 CSCL 20D

The prediction of the complete flow field in a turbine passage is an extremely difficult task due to the complex three dimensional pattern which contains separation and attachment lines, a saddle point and horseshoe vortex. Whereas, in principle such a problem can be solved using full Navier-Stokes equations, in reality methods based on a Navier-Stokes solution procedure encounter difficulty in accurately predicting surface quantities (e.g., heat transfer) due to grid limitations imposed by the speed and size of the existing computers. On the other hand the overall problem is strongly three dimensional and too complex to be analyzed by the current design methods based on inviscid and/or viscous strip theories. Thus there is a strong need for enhancing the current prediction techniques through inclusion of 3-D viscous effects. A potentially simple and cost effective way to achieve this is to use a prediction method based on three dimensional boundary layer (3-DBL) theory. The major objective of this program is to assess the applicability of such a 3-DBL approach for the prediction of heat loads, boundary layer growth, pressure losses and streamline skewing in critical areas of a turbine passage. A brief discussion of the physical problem addressed here along with the overall approach is presented. Author

**N86-11510*#** Pratt and Whitney Aircraft Group, East Hartford, Conn.

**COOLANT PASSAGE HEAT TRANSFER WITH ROTATION. A PROGRESS REPORT ON THE COMPUTATIONAL ASPECTS**

L. D. ACETO and G. J. STURGESS *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 111-116 Oct. 1983 refs

Avail: NTIS HC A11/MF A01 CSCL 20D

Turbine airfoils are subjected to increasingly higher heat loads which escalate the cooling requirements in order to satisfy life goals for the component materials. If turbine efficiency is to be maintained, however, cooling requirements should be as low as possible. To keep the quantity of cooling air bounded, a more efficient internal cooling scheme must be developed. One approach is to employ airfoils with multipass cooling passages that contain devices to augment internal heat transfer while limiting pressure drop. Design experience with multipass cooling passage airfoils has shown that a surplus of cooling air must be provided as a margin of safety. This increased cooling air leads to a performance penalty. Reliable methods for predicting the internal thermal and aerodynamic performance of multipass cooling passage airfoils would reduce or eliminate the need for the safety margin of surplus cooling air. The objective of the program is to develop and verify improved analytical methods that will form the basis for design technology which will result in efficient turbine components with improved durability without sacrificing performance. The objective will be met by: (1) establishing a comprehensive experimental data base that can form the basis of an empirical design system; (2) developing computational fluid dynamic techniques; and (3) analyzing the information in the data base with both phenomenological modeling and mathematical modeling to derive a suitable design and analysis procedure. Author

**N86-11511*#** Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.

**JET ARRAY IMPINGEMENT HEAT TRANSFER CHARACTERISTICS**

L. W. FLORSCHUETZ and D. E. METZGER *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 117-128 Oct. 1983 refs

Avail: NTIS HC A11/MF A01 CSCL 20D

Two dimensional arrays of circular air jets impinging on a heat transfer surface parallel to the jet orifice plate are considered. The jet flow, after impingement, is constrained to exit in a single direction along the channel formed by the jet orifice plate and the heat transfer surface. In addition to the crossflow which originates from the jets following impingement, an initial crossflow is present which approaches the array through an upstream extension of the channel. The configurations considered are intended to model the impingement cooled midchord region of gas turbine airfoils in cases where an initial crossflow is also present. A major objective is determination of the effect of initial crossflow air temperature relative to jet array air temperature on impingement surface heat fluxes. Author

**N86-11514*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**BURNER LINER THERMAL/STRUCTURAL LOAD MODELLING**

R. J. MAFFEO *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 159-163 Oct. 1983

(Contract NAS3-23272)

Avail: NTIS HC A11/MF A01 CSCL 20K

The objective of this program is to develop a thermal data transfer computer program module for the burner liner thermal structural load modeling program. This will be accomplished by (1) reviewing existing methodologies for thermal data transfer and selecting three heat transfer codes for application in this program (2) evaluating the selected codes to establish criteria for developing a computer program module to transfer thermal data from the heat transfer codes to selected stress analysis codes; (3) developing the automated thermal load transfer module; and (4) verifying and documenting the module. In aircraft turbine engine hot section components, cyclic thermal stresses are the most important damage mechanism. Consequently, accurate and reliable prediction of thermal loads is essential to improving durability. To achieve this goal, a considerable effort over the past 20 years has been devoted to the acquisition of engine temperature test data, as well as the development of accurate, reliable, and efficient computer codes for the prediction of steady state and transient temperatures and for the calculation of elastic and inelastic cyclic stresses and strains in hot section components. There is a need for continued development of these codes, because the availability of more accurate analysis techniques for complex configurations has enabled engine designers to use more sophisticated designs to achieve higher cycle efficiency and reduce weight. Author

**N86-11516*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**THE 3D INELASTIC ANALYSIS METHODS FOR HOT SECTION COMPONENTS**

L. T. DAME and R. L. MCKNIGHT *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 175-177 Oct. 1983 refs

Avail: NTIS HC A11/MF A01 CSCL 20K

The objective of this research is to develop an analytical tool capable of economically evaluating the cyclic time dependent plasticity which occurs in hot section engine components in areas of strain concentration resulting from the combination of both mechanical and thermal stresses. The techniques developed must be capable of accommodating large excursions in temperatures with the associated variations in material properties including plasticity and creep. The overall objective of this proposed program is to develop advanced 3-D inelastic structural/stress analysis methods and solution strategies for more accurate and yet more cost effective analysis of combustors, turbine blades, and vanes. The approach will be to develop four different theories, one linear and three higher order with increasing complexities including embedded singularities. Author

**N86-11517*#** Pratt and Whitney Aircraft, East Hartford, Conn.

**THE 3-D INELASTIC ANALYSIS METHODS FOR HOT SECTION COMPONENTS (BASE PROGRAM)**

E. S. TODD *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 179-180 Oct. 1983

Avail: NTIS HC A11/MF A01 CSCL 20K

The objective of this program is to produce a series of new computer codes that permit more accurate and efficient three dimensional inelastic analysis of selected hot section components - combustor liners, turbine blades and turbine vanes. The computer codes embody a progression of mathematical models and are streamlined to take advantage of geometrical features, loading conditions, and forms of material response that distinguish each group of selected components. Author

**N86-11519*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**HOST LINER CYCLIC FACILITIES**

D. SCHULTZ *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 195-204 Oct. 1983

Avail: NTIS HC A11/MF A01 CSCL 20K

The HOST Liner Cyclic Program is utilizing two types of test apparatus, rectangular box rigs and a full annular rig. To date two quartz lamp cyclic box rigs have been tested and a third is to begin testing in late October 1983. The box rigs are used to evaluate 5x8 inch rectangular linear samples. A 21 inch diameter outer liner simulator is also being built up for testing beginning in April 1984. All rigs are atmospheric rigs. The first box rig, a three 6-kVA lamp installation, was operated under adverse conditions to determine feasibility of using quartz lamps for cyclic testing. This work was done in December 1981 and looked promising. The second box rig, again using three 6-kVA lamps, was operated to obtain instrumentation durability information and initial data input to a Finite Element Model. This limited test program was conducted in August 1983. Five test plates were run. Instrumentation consisted of strain gages, thermocouples and thermal paint. The strain gages were found to fail at 1200 F as expected though plates were

heated to 1700 F. The third box rig, containing four 6-kVA lamps, is in build up for testing to begin in late October 1983. In addition to 33 percent greater power input, this rig has provision for 400 F backside line cooling air and a viewing port suitable for IR camera viewing. The casing is also water cooled for extended durability.
Author

**N86-11520*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**LIFE PREDICTION AND CONSTITUTIVE BEHAVIOR**
G. R. HALFORD *In its* Turbine Eng. Hot Sect. Technol. (HOST) p 205-207 Oct. 1983
Avail: NTIS HC A11/MF A01 CSCL 20K

One of the primary drivers that prompted the initiation of the hot section technology (HOST) program was the recognized need for improved cyclic durability of costly hot section components. All too frequently, fatigue in one form or another was directly responsible for the less than desired durability, and prospects for the future weren't going to improve unless a significant effort was mounted to increase our knowledge and understanding of the elements governing cyclic crack initiation and propagation lifetime. Certainly one of the important factors is the ability to perform accurate structural stress-strain analyses on a routine basis to determine the magnitudes of the localized stresses and strains since it is these localized conditions that govern the initiation and crack growth processes. Developing the ability to more accurately predict crack initiation lifetimes and cyclic crack growth rates for the complex loading conditions found in turbine engine hot sections is of course the ultimate goal of the life prediction research efforts. It has been found convenient to divide the research efforts into those dealing with nominally isotropic and anisotropic alloys; the latter for application to directionally solidified and single crystal turbine blades.
Author

**N86-11521*#** Pratt and Whitney Aircraft, East Hartford, Conn.
**CREEP FATIGUE LIFE PREDICTION FOR ENGINE HOT SECTION MATERIALS (ISOTROPIC)**
V. MORENO *In* NASA. Lewis Research Center Turbine Eng. Hot Sect. Technol. (HOST) p 209-210 Oct. 1983
(Contract NAS3-23288)
Avail: NTIS HC A11/MF A01 CSCL 20K

The activities performed during the first year of the NASA HOST Program, Creep Fatigue Life Prediction for Engine Hot Section Materials (Isotropic), being conducted by Pratt & Whitney Aircraft are summarized. The program is a 5 year, two part effort aimed at improving the high temperature crack initiation prediction technology for gas turbine hot section components. Significant results of the program produced thus far are discussed. Cast B1900 + Hf and wrought IN 718 were selected as the base and alternate materials, respectively. A single heat of B1900 + Hf was obtained and test specimens fabricated. The material was characterized with respect to grain size, gamma prime size, carbide distribution, and dislocation density. Monotonic tensile and creep testing has shown engineering properties within anticipated scatter for this material. Examination of the tensile tests has shown a transition from inhomogeneous planar slip within the grains at lower temperatures to more homogeneous matrix deformation. Examination of the creep tests has shown a transgranular failure mode at 1400 F and an intergranular failure mode at 1600 F and 1800 F.
Author

**N86-11522*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A STUDY OF THE CORNERING FORCES GENERATED BY AIRCRAFT TIRES ON A TILTED, FREE-SWIVELING NOSE GEAR**
R. H. DAUGHERTY and S. M. STUBBS Oct. 1985 30 p refs
(NASA-TP-2481; L-15954; NAS 1.60:2481) Avail: NTIS HC A03/MF A01 CSCL 20K

An experimental investigation was conducted to study the effect of various parameters on the cornering forces produced by a rolling aircraft tire installed on a tilted, free-swiveling nose gear. The parameters studied included tilt angle, trial, tire inflation pressure, rake angle, vertical load, and whether or not a twin tire configuration corotates. These parameters were evaluated by measuring the cornering force produced by an aircraft tire installed on the nose gear of a modified vehicle as it was towed slowly. Cornering force coefficient increased with increasing tilt angle. Increasing trial or rake angle decreased the magnitude of the cornering force coefficient. Tire inflation pressure had no effect on the cornering force coefficient. Increasing vertical load decreased the cornering force coefficient. When the tires of a twin tire system rotated independently, the cornering force coefficients were the same as those for the single-tire configuration. When the twin tire system was made to corotate, however, the cornering force coefficients increased significantly.
Author

**N86-11523*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AEROELASTIC MODEL HELICOPTER ROTOR TESTING IN THE LANGLEY TDT**
W. R. MANTAY, W. T. YEAGER, JR., M. N. HAMOUDA, R. G. CRAMER, JR., and C. W. LANGSTON Jun. 1985 19 p refs
Presented at AHS Specialists' Meeting on Helicopter Test Methodology, 29 Oct. - 1 Nov. 1984, Williamsburg, Va.
(Contract DA PROJ. 1L1-62209-AH-76)
(NASA-TM-86440; NAS 1.15:86440; USAAVSCOM-TM-85-B-5)
Avail: NTIS HC A02/MF A01 CSCL 20K

Wind-tunnel testing of a properly scaled aeroelastic model helicopter rotor is considered a necessary phase in the design development of new or existing rotor systems. For this reason, extensive testing of aeroelastically scaled model rotors is done in the Transonic Dynamics Tunnel (TDT) located at the NASA Langley Research Center. A unique capability of this facility, which enables proper dynamic scaling, is the use of Freon as a test medium. A description of the TDT and a discussion of the benefits of using Freon as a test medium are presented. A description of the model test bed used, the Aeroelastic Rotor Experimental System (ARES), is also provided and examples of recent rotor tests are cited to illustrate the advantages and capabilities of aeroelastic model rotor testing in the TDT. The importance of proper dynamic scaling in identifying and solving rotorcraft aeroelastic problems, and the importance of aeroelastic testing of model rotor systems in the design of advanced rotor systems are demonstrated.
Author

**N86-11524*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**STRESS ANALYSES OF B-52 PYLON HOOKS**
W. L. KO and L. S. SCHUSTER Oct. 1985 33 p refs
(NASA-TM-84924; H-1221; NAS 1.15:84924) Avail: NTIS HC A03/MF A01 CSCL 20K

The NASTRAN finite element computer program was used in the two dimensional stress analysis of B-52 carrier aircraft pylon hooks: (1) old rear hook (which failed), (2) new rear hook (improved geometry), (3) new DAST rear hook (derated geometry), and (4) front hook. NASTRAN model meshes were generated by the aid of PATRAN-G computer program. Brittle limit loads for all the four hooks were established. The critical stress level calculated from NASTRAN agrees reasonably well with the values predicted from the fracture mechanics for the failed old rear hook.
Author

**N86-11525*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**A COMPARISON OF MEASURED AND CALCULATED THERMAL STRESSES IN A HYBRID METAL MATRIX COMPOSITE SPAR CAP ELEMENT**
J. M. JENKINS, A. H. TAYLOR (NASA, Langley Research Center), and I. F. SAKATA (Lockheed California Co., Burbank) Sep. 1985 20 p refs
(NASA-TM-86729; H-1289; NAS 1.15:86729) Avail: NTIS HC A02/MF A01 CSCL 20K

A hybrid spar of titanium with an integrally brazed composite, consisting of an aluminum matrix reinforced with boron-carbide-coated fibers, was heated in an oven and the resulting thermal stresses were measured. Uniform heating of the spar in an oven resulted in thermal stresses arising from the effects of dissimilar materials and anisotropy of the metal matrix composite. Thermal stresses were calculated from a finite element structural model using anisotropic material properties deduced from constituent properties and rules of mixtures. Comparisons of calculated thermal stresses with measured thermal stresses on the spar are presented. It was shown that failure to account for anistropy in the metal matrix composite elements would result in large errors in correlating measured and calculated thermal stresses. It was concluded that very strong material characterization efforts are required to predict accurate thermal stresses in anisotropic composite structures. Author

**N86-11540*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMPUTATIONAL STRUCTURAL MECHANICS: A NEW ACTIVITY AT THE NASA LANGLEY RESEARCH CENTER**

N. F. KNIGHT, JR. and W. J. STROUD Sep. 1985 39 p refs
Presented at 22nd Ann. Tech. Meeting of the Soc. of Eng. Sci., University Park, Pa., 7-9 Oct. 1985
(NASA-TM-87612; NAS 1.15:87612) Avail: NTIS HC A03/MF A01 CSCL 20K

Complex structures considered for the late 1980's and early 1990's include composite primary aircraft structure and the space station. These structures will be much more difficult to analyze than today's structures and necessitate a major upgrade in computerized structural analysis technology. A new research activity in structural analysis, the computational structural mechanics (CSM) was initiated. The objective of the CSM activity is to develop advanced structural analysis technology that will exploit modern and emerging computers such as computers with vector and/or parallel processing capabilities. The three main research activities underway in CSM include: (1) structural analysis methods development; (2) a software testbed for evaluating the methods; and (3) numerical techniques for parallel processing computers. The motivation and objectives of the CSM activity are presented and CSM activity is described. The current CSM research thrusts, and near and long term CSM research thrusts are outlined. E.A.K.

# 13

# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-11789**

**SMALL FORMAT MICROLIGHT SURVEYS**

R. W. GRAHAM (Aerial Imaging Systems, Ltd., Amersham, England), R. E. READ, and J. KURE (International Institute for Aerial Survey and Earth Sciences, Enschede, Netherlands) ITC Journal (ISSN 0303-2434), no. 1, 1985, p. 14-20.

Conventional survey aircraft are designed to meet photogrammetric requirements of mapping. For less exacting coverage, where metric accuracy is not important, there is an urgent need for a more economical and appropriate method of obtaining primary data. This article summarizes the results of research on small format microlight surveys (SFMS)-including the types of aircraft, types of camera, various lenses and films-in an attempt to evaluate SFMS for use in urban and earth resource surveys. Author

**A86-12447**

**THE EFFECT OF CHANGES IN AIRCRAFT NOISE EXPOSURE**

G. J. RAW and I. D. GRIFFITHS (Surrey, University, Guildford, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 101, July 22, 1985, p. 273-275. Research supported by the Economic and Social Research Council.

Langdon and Griffiths (1982) have presented evidence that decreases in road traffic noise have a greater beneficial effect on annoyance caused by noise than would be predicted from a function derived from studies of steady state noise conditions. The same type of study has now been applied to aircraft noise using a regression analysis. It was found that an increase or decrease in aircraft noise results in a change in annoyance over 50 percent greater than would be predicted by using the steady state regression line. Hence, the change itself has an important effect in addition to the effect of the final noise level reached. C.D.

**N86-10713#** Air Command and Staff Coll., Maxwell AFB, Ala.

**ROTARY-WING OPERATIONS IN A MICROBURST ENVIRONMENT**

E. E. MACE Apr. 1985 43 p
(AD-A156695; ACSC-85-1670) Avail: NTIS HC A03/MF A01 CSCL 04B

Microburst wind shear has been directly or indirectly involved in 28 aircraft incidents or accidents since 1964. Following the last major aircraft accident attributed to microburst wind shear in 1982, a major effort was undertaken to study the hazard. The majority of the work that has been accomplished deals with the publicity of the phenomenon to the aviation community and with acceptable methods of detecting it before it occurs. This study explores the background, detection systems and special considerations of helicopter operations in relation to microburst induced wind shear. Included are subjective hazards, aircraft response and recommended pilot actions to successfully penetrate the wind shear if inadvertently encountered. The study recommends that it be used as an interim measure to supplement existing microburst wind shear information and that additional helicopter microburst testing be conducted. Author (GRA)

**N86-10720#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abt. fuer Physik der Atmosphaere.

**COMPARATIVE FLIGHT MEASUREMENT OF ICING PARAMETERS FOR THE PROPELLER AIRCRAFT DO-28D2 OF THE TEST STATION 61 OF THE DFVLR AND FOR THE DFVLR AIRCRAFT FALON 20E IN STRATUS CLOUDS**

K. P. SCHICKEL and K. UWIRA (Bundesamt fuer Wehrtechnik und Beschaffung, Landsberg/Lech, West Germany) Dec. 1984 52 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-941)
(DFVLR-FB-85-16; ISSN-0171-1342) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 15.50

Two aircraft of different types and instrumentation were compared during a flight operation in icing stratus clouds. The results of the measurements are comparable. It is established that differences between icing and nonicing stratus clouds can be detected in infrared satellite pictures; possible causes of these differences are given. The improvement of forecasts of icing stratus clouds is planned. Author (ESA)

**N86-10721#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abteilung Wolkenphysik.

**USER MANUAL FOR THE FALCON SYSTEM**

Feb. 1985 134 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-936)
(DFVLR-MITT-85-08; ISSN-0176-7739) Avail: NTIS HC A07/MF A01; DFVLR, Cologne DM 36.50

The user manual for the meteorological research aircraft Falcon E, operated by DFVLR, is presented. The system and its technical data are described. The meteorological mission possibilities are discussed, and measuring campaigns are reviewed. Basic and special equipment is described. The onboard data acquisition system and the operational data evaluation programs are discussed. Author (ESA)

**N86-11735*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
**METEOROLOGICAL AND ENVIRONMENTAL INPUTS TO AVIATION SYSTEMS**
D. W. CAMP, ed. and W. FROST, ed. (Tennessee Univ. Space Inst.) Sep. 1985 144 p refs Workshop held in Tullahoma, Tenn., 26-28 Oct. 1983; sponsored by NASA, NOAA, FAA, DOD, and Office of the Federal Coordinator for Meteorology
(Contract NAS8-36177)
(NASA-CP-2388; NAS 1.55:2388) Avail: NTIS HC A07/MF A01 CSCL 04B

An overview of meteorological parameters effecting aircraft flight is presented.

**N86-11736*#** Federal Aviation Administration, Washington, D.C. Weather Coordination Program.
**OVERVIEW OF METEOROLOGICAL INPUTS TO NASP**
J. C. DZIUK *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 17-21 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

An overview of meteorological systems for forecasting flight conditions is presented. The types of equipment used to gather the information used to prepare pilot briefings and in flight advisories is described. Possible improvements to the systems are classified as short term or long term. G.L.C.

**N86-11737*#** Delta Air Lines, Inc., Atlanta, Ga.
**AIRLINE METEOROLOGICAL REQUIREMENTS**
C. L. CHANDLER and J. PAPPAS (Western Airlines, Los Angeles, Calif.) *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 21-23 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

A brief review of airline meteorological/flight planning is presented. The effects of variations in meteorological parameters upon flight and operational costs are reviewed. Flight path planning through the use of meteorological information is briefly discussed. G.L.C.

**N86-11738*#** Newton (Dennis W.), Reno, Nev.
**GENERAL AVIATION'S METEOROLOGICAL REQUIREMENTS**
D. NEWTON *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 23-26 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

Communication of weather theory and information about weather service products to pilots in an accurate and comprehensible manner is essential to flying safety in general. Probably no one needs weather knowledge more than the people who fly through it. The specific subject of this overview is General Aviation's Meteorological Requirements. G.L.C.

**N86-11739*#** Business and Commercial Aviation, White Plains, N.Y.
**CORPORATE/COMMUTER AIRLINES METEOROLOGICAL REQUIREMENTS**
J. W. OLCOTT *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 27-29 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

The meteorological information requirements of corporate and commuter airlines are reviewed. The skill level and needs of this class of aviator were assessed. An overview of the methodology by which meteorological data is communicated to these users is presented. G.L.C.

**N86-11740*#** Federal Aviation Administration, Atlantic City, N.J.
**OVERVIEW OF FAA'S AIRCRAFT ICING PROGRAM**
L. CZEKALSKI *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 30-34 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

An overview of the FAA's icing program is presented. The program involves certification of various types of aircraft for flight in known icing conditions, the study of icing conditions, and the preparation of certification standards. Test and technology transfer programs are also included. G.L.C.

**N86-11741*#** National Aeronautics and Space Administration, Washington, D. C.
**OVERVIEW OF NASA'S PROGRAMS**
A. R. TOBIASON *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 34-39 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

An overview of some of NASA's aviation related programs is presented. The areas discussed include: (1) severe storms; (2) clear air turbulence; (3) icing; (4) fog; and (5) landing systems. G.L.C.

**N86-11742*#** Coast Guard, Elizabeth City, N.C.
**ADVERSE WEATHER IMPACT ON AVIATION SAFETY, INVESTIGATION AND OVERSIGHT**
M. J. SMITH *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 43-48 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

A brief review of the weather factors that effect aviation safety with respect to U.S. Coast Guard operations is presented. Precise meteorological information is an absolute necessity to the Coast Guard which must conduct life saving and rescue operations under the worst of weather conditions. Many times the weather conditions in which they operate are the cause of or a contributing factor to the predicament from which they must execute a rescue operation. G.L.C.

**N86-11743*#** Naval Research Lab., Washington, D. C. Experimental Cloud Physics Section.
**A NEW CHARACTERIZATION OF THE ICING ENVIRONMENT BELOW 10,000 FEET AGL FROM 7,000 MILES OF MEASUREMENTS IN SUPERCOOLED CLOUDS**
R. K. JECK *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 51-55 Sep. 1985 refs
Avail: NTIS HC A07/MF A01 CSCL 04B

A growing requirement over the past decade for a new assessment of aircraft icing conditions in wintertime clouds at altitudes up to about 10,000 feet is discussed. The requirement was documented in past workshops and comes primarily from the helicopter community which wants ice-protected rotorcraft to meet increasing demands for all-weather operations. Currently, only a few of the larger helicopters are equipped with certification of ice-protection devices. This is because the current FAA criteria for design and certification of ice-protection equipment results in power and payload penalties that smaller rotorcraft cannot tolerate. The FAA criteria were actually designed for large, transport-category aircraft capable of flying to 20,000 feet or more. For this reason, there have been concerns that the current criteria may be too severe for low-performance aircraft, such as helicopters, which generally operate at altitudes below 10,000 feet. G.L.C.

**N86-11744*#** Federal Aviation Administration, Atlantic City, N.J.
**A NEW CHARACTERIZATION OF SUPERCOOLED CLOUDS BELOW 10,000 FEET AGL**
C. O. MASTERS *In* NASA. Marshall Space Flight Cente Meteorol. and Environ. Inputs to Aviation Systems p 56-59 Sep. 1985 refs
Avail: NTIS HC A07/MF A01 CSCL 04B

Icing caused by supercooled clouds below 10,000 feet were characterized with a view toward a change in FAA standards fo civil aircraft ice protection standards. Current techniques in clou physics were employed. G.L.C

**N86-11745*#** Spectron Development Labs., Inc., Costa Mesa, Calif.

**ADVANCE PARTICLE AND DOPPLER MEASUREMENT METHODS**

C. BUSCH *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 61-62 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

Particle environments, i.e., rain, ice, and snow particles are discussed. Two types of particles addressed are: (1) the natural environment in which airplanes fly and conduct test flights; and (2) simulation environments that are encountered in ground-test facilities such as wind tunnels, ranges, etc. There are characteristics of the natural environment that one wishes to measure. The liquid water content (LWC) is the one that seems to be of most importance; size distribution may be of importance in some applications. Like snow, the shape of the particle may be an important parameter to measure. As one goes on to environment in simulated tests, additional parameters may be required such as velocity distribution, the velocity lag of the particle relative to the aerodynamic flow, and the trajectory of the particle as it goes through the aerodynamic flow and impacts on the test object. G.L.C.

**N86-11746*#** Flying Tigers-Retired, San Pedro, Calif.

**DEVELOPMENT OF A WIND SHEAR PERFORMANCE ENVELOPE**

J. H. BLISS *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 62-65 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

It is quite important that the airplane performance during a continuing headwind loss be understood. Lack of consideration of this characteristic can result in assuming almost twice the performance than that which the airplane actually has during severe wind shear at high descent rates. The example data relates to the Boeing 727-200, but the characteristics are applicable to any airplane. G.L.C.

**N86-11747*#** Tennessee Univ. Space Inst., Tullahoma. Atmospheric Sciences Div.

**LABORATORY MODEL OF FLIGHT THROUGH WIND SHEAR**

W. FROST *In* NASA. Marshall Space Flight Center Meteorol and Environ. Inputs to Aviation Systems p 65-67 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

The simulation of an aircraft flying through a downdraft or microburst is presented. The simulation was performed under the conditions of constant takeoff thrust. The resulting wind shear conditions were filmed and examined for possible pilot corrective action in the future. G.L.C.

**N86-11748*#** Toronto Univ. (Ontario). Inst. for Aerospace Studies.

**A MODEL OF A DOWNBURST, A WIND TUNNEL PROGRAM ON PLANETARY BOUNDARY LAYER, AND AIRSHIP IN TURBULENCE**

B. ETKIN *In* NASA. Marshall Space Flight Center Meteorol. and Environ. Inputs to Aviation Systems p 68-73 Sep. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

An engineering model of microbursts was developed as an aid to possible future flight simulation in wind shear. Planetary boundary layer and high altitude turbulence were also modeled. G.L.C.

**N86-11758#** Air Command and Staff Coll., Maxwell AFB, Ala.

**RECOGNITION AND CONTROL OF LOW LEVEL WIND SHEAR**

W. G. ROGERS Apr. 1985 108 p
(AD-A156500; ACSC-85-2215) Avail: NTIS HC A06/MF A01 CSCL 04B

This is a two hour lesson plan/handbook and slide presentation on low level wind shear. The project was developed for the SAC Instrument Flight Center to be used in their curriculum. The lesson plan is designed to enable SAC instructors to effectively teach other pilots how to understand, recognize, and cope with low level wind shear hazards. The lesson plan addresses the effects, causes, detection, and control of low level wind shear. Author (GRA)

## 15

## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-10180**

**FINITE WORDLENGTH DESIGN OF DIGITAL KALMAN FILTERS FOR STATE ESTIMATION**

D. WILLIAMSON (New South Wales, University, Kensington, Australia) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-30, Oct. 1985, p. 930-939. refs

The optimal design of a Kalman filter is considered with respect to its finite wordlength (FWL) characteristics taking into account the roundoff noise due to state quantization. The issues are particularly relevant in the design of FWL Kalman filters for continuous-time systems operating under a fast sampling rate. In this respect, the results demonstrate one compromise between the selection of the sampling rate and the selection of the state wordlength. The optimum filter structure includes state residue feedback compensation which can result in the saving of many bits of additional state wordlength. Author

**A86-10191**

**STOCHASTIC DYNAMIC SYSTEM SUBOPTIMAL CONTROL WITH UNCERTAIN PARAMETERS**

M. H. LEE, W. J. KOLODZIEJ, and R. R. MOHLER (Oregon State University, Corvallis) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-21, Sept. 1985, p. 594-600. refs
(Contract N00014-81-K-0814)

The control of a linear system with random coefficients is studied here. The cost function is of a quadratic form and the random coefficients are assumed to be partially observable by the controller. By means of the stochastic Bellman equation, the optimal control of stochastic dynamic models with partially observable coefficients is derived. The optimal control is shown to be a linear function of the observable states and a nonlinear function of random parameters. The theory is applied to an optimal control design of an aircraft landing in wind gust. Author

**A86-10929#**

**LOGISTICS CONSIDERATIONS FOR DESIGN ENGINEERS**

F. J. LAUBER (McDonnell Douglas Astronautics Co., St. Louis, MO) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 6 p.
(AIAA PAPER 85-3056)

Designers of weapon systems are facing new government emphasis on providing readiness and support for new designs at an affordable and balanced life-cycle cost. Readiness and support will now receive comparable emphasis with performance, cost and schedule as a criterion for evaluating programs. To help designers adjust to this new emphasis, this paper defines logistic support, describes associated costs for operating and supporting weapon systems, and identifies the timing required to integrate support considerations into the design process. With this knowledge, designers can call for logistics assistance in the same manner that they now call for other Systems Engineering expertise to optimize the final design configuration. Author

**A86-10946#**

**INTEGRATED SYSTEMS FOR COMPONENT SPECIFIC DESIGN AND ANALYSIS**

P. J. ROONEY and J. H. JACKO (Avco Corp., Avco Lycoming Stratford Div., CT) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 5 p.
(AIAA PAPER 85-3097)

The use of integrated design and analysis tools can significantly increase the ability to address multiple alternatives and to identify optimal solutions for component design. Key elements in developing integrated systems are a single part definition, a comprehensive database, the user interface, and component specific software modules. This paper describes one approach to the design and implementation of integrated systems for gas turbine components through the development of a system for Disc Design. Author

**A86-10948#**

**CONSIDERATIONS FOR THE IMPLEMENTATION OF INTELLIGENT WORKSTATION NETWORKS**

H. JACOBSON and A. GORDON (Boeing Aerospace Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 6 p.
(AIAA PAPER 85-4001)

Intelligent workstations linked together in Local Area Networks (LANS) are ushering in a new era in engineering/scientific computing. Powerful interactive graphics software and high resolution output presentation capabilities can now be provided economically at the engineer's desk. Paperless electronic data flows between functions and departments are technically feasible. This paper describes the Boeing Aerospace Company's experiences with the initial deployment of intelligent workstations in LANS. The issues discussed include in-house customer relations, software vendors, user experiences, potential pitfalls, and future plans. Author

**A86-11053#**

**PAN AIR CONSULTATIONS USING EXPERT SYSTEM TECHNIQUES**

R. S. CONNER (Boeing Military Airplane Co., Seattle, WA), D. J. PURDON (Boeing Computer Services Co., Seattle, WA), and F. K. WAMSLEY (Asymetrix Corp., Bellevue, WA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 7 p. refs
(AIAA PAPER 85-4094)

Expert system techniques are proposed to aid aircraft design engineers who run the PAN AIR program within the constraints of a project environment. Expert systems are programs which mimic human problem solving by performing symbolic computations. Performing all the tasks associated with running PAN AIR would require knowledge of proper geometric modeling, program input options and output analysis methods. A prototype of a program input option expert system was built. It demonstrates a very user friendly interface to the code by querying the user about the problem in general terms and translating the responses into a PAN AIR input deck. Author

**A86-11123**

**MATCHED PROCESSORS FOR QUANTIZED CONTROL - A PRACTICAL PARALLEL-PROCESSING APPROACH**

E. H. FERIA (College of Staten Island, NY) International Journal of Control (ISSN 0020-7179), vol. 42, Sept. 1985, p. 695-713. refs

Deterministic 'quantized control' problems are investigated from a novel and often computationally feasible 'matched processors' (MPs) perspective. It is noted that a bank of independent MPs, each matched to an admissible decision sequence, can evaluate, given the state and remaining duration, the dynamic performance cost-to-go values corresponding to a suitably selected 'small' subset of all admissible decision sequences. By choosing the best admissible decision sequence in this subset and using its first decision at each stage a computationally feasible and generally suboptimum MP control scheme is produced. This scheme is found to be ideally suited for very-large-scale integration. In particular, for processes that are linear in the state and performance criteria that are quadratic in the state, the cost-to-go reduces to a simple quadratic function of the given state which in turn results in an MP control scheme structure similar to offered VLSI-based digital computers. It is demonstrated that the proposed scheme performs quite well in two experimental examples. Author

**A86-11401***

**COMPUTERS IN AEROSPACE CONFERENCE, 5TH, LONG BEACH, CA, OCTOBER 21-23, 1985, TECHNICAL PAPERS**

Conference sponsored by AIAA, Association for Computing Machinery, NASA, and IEEE. New York, AIAA, 1985, 519 p. For individual items see A86-11402 to A86-11470.

Among the topics discussed are: access control models for a distributed CAIS-conforming system; a knowledge-based advisory system for casualty procedures; and automated interactive simulation modeling system. Consideration is also given to: reusable software concepts and software development methodologies; the electronic device aspects of neutral network memories; an expert system for automated satellite anomaly resolution; and the use of automatic programming techniques for fault-tolerant computing systems. Among additional topics discussed are: systems approaches to software fault tolerance; a Space Shuttle navigation validation system; and a vision-based road following system for an autonomous land vehicle. I.H.

**A86-11411#**

**THE AUTOMATED INTERACTIVE SIMULATION MODELING SYSTEM**

N. A. KUO (USAF, Bedford, MA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 84-91.
(AIAA PAPER 85-5055)

A new general purpose simulation modeling tool, AISIM (Automated Interactive Simulation Modeling System), has been developed by Air Force System Command's Electronic Systems Division under the direction of Air Force Program Element 64740F, Computer Resource Management Technology. AISIM is designed to provide quick answers to system performance questions during the conceptual phase of a system's acquisition. AISIM has undergone many tests and is currently in the initial operating capability phase of software development. Initial test results indicate potential for wide application to the study of communication nets, computer system architectures, and data processing functions during the conceptual stages of system development. This paper introduces the reader to AISIM - its model building capabilities and its five user interfaces. Author

**A86-11441#**

**MULTITASK SCHEDULING FOR TIME-CRITICAL APPLICATIONS**

J. F. READY (Hunter and Ready, Inc., Palo Alto, CA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 294-304.
(AIAA PAPER 85-6008)

A hierarchy of control loops is employed as an example to demonstrate the most efficient software methodology for testing synchronous, hybrid, and asynchronous (C3I and EW) time-critical avionics applications. It is noted that, as the cyclic control loops increase in complexity, the software must become aware of multiple functions and the priorities of such functions, which leads to a consideration of a multitasking methodology as a practical solution. Illustrations including code examples in Ada are presented which provide a step-by-step guide through the subject of multitask scheduling for time-critical applications. B.J

**A86-11442#**

### SOFTCOST - A USER-FRIENDLY SOFTWARE COST ESTIMATION TOOL

D. J. REIFER and M. H. HILL (Reifer Consultants, Inc., Torrance, CA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 305-313. refs
(AIAA PAPER 85-6009)

The SoftCost estimating tool, its features, and initial user experiences with it in operational environments are described. SoftCost is a software system that integrates a powerful screen editor, a hybrid parametric software estimation model, and a flexible report generator with Gantt/PERT charting capabilities into an user-friendly environment where software project costs can be estimated quickly and accurately under a wide variety of situations. The tool builds on both the strengths and weaknesses of other similar packages available in the public domain. These features and SoftCost's approach to interfacing with the management user are explained in depth as the paper relates how the tool's goals of user-friendliness, fidelity, and flexibility were achieved in the tool's design. Initial experiences with the tool on both military and commercial projects are described. Author

**A86-11446#**

### BOEING STRESS ANALYSIS WORKSTATION DEVELOPMENT

D. C. JACK and F. GAMA-LOBO (Boeing Co., Seattle, WA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 349-354.
(AIAA PAPER 85-6014)

With the increased design productivity resulting from a CAD/CAM environment, it is evident that traditional hand methods of strength checking airframe structures are rapidly becoming inadequate. This paper describes the development of a pilot stress analysis workstation program which, using a MASSCOMP MC500 workstation, takes full advantage of today's microcomputer capability to address this situation. The stress workstation fully synthesizes the digital product definition, the mainframe internal loads analysis, and classical ultimate, fatigue and damage tolerance strength-checks into a user-friendly, integrated system. The system uses modern data base management and graphic display techniques to provide the analyst with a real-time comprehensive analysis with an innovative informative display of results which parallels the current stress analysis. Requirements, program design and structure, and engineering acceptance are discussed in detail. Author

**A86-11450#**

### PREDICATE/TRANSITION NETWORK ANALYSIS OF REDUNDANT CHANNEL SYNCHRONIZATION

L. A. BARTON, D. B. MULCARE, L. E. DOWNING (Lockheed-Georgia Co., Marietta), and R. J. LEBLANC (Georgia Institute of Technology, Atlanta) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 374-379.
(AIAA PAPER 85-6020)

The predicate/transition network analysis technique provides a powerful tool for modeling and analyzing concurrent systems with discrete states. In a recent project, a predicate/transition network was used to model the cross-channel synchronization design for a quadruplex digital flight control system (DFCS). An analysis program was developed and applied in exercising the network to confirm its proper operation, i.e., its correct sequencing of state transitions. This tool was then extended by the use of Ada tasking to a time-based simulation that permits the inclusion of nonideal timing effects that tend to be present in practical systems. Although it possesses more general utility, the predicate/transition network analysis program has provided the capacity to rigorously verify DFCS designs on an analytical basis, rather than by trial and error methods such as breadboarding. Its development has also afforded considerable design and programming experience with the Ada programming language, especially with regard to applications of tasking, which have been found to be particularly well suited to time-based simulations. Author

**A86-11452*#** Charles River Associates, Inc., Cambridge, Mass.

### PERFORMANCE ANALYSIS OF A FAULT INFERRING NONLINEAR DETECTION SYSTEM ALGORITHM WITH INTEGRATED AVIONICS FLIGHT DATA

A. K. CAGLAYAN, P. M. GODIWALA (Charles River Analytics, Inc., Cambridge, MA), and F. R. MORREL (NASA, Langley Research Center, Hampton, VA) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 391-398. refs
(AIAA PAPER 85-6022)

This paper presents the performance analysis results of a fault inferring nonlinear detection system (FINDS) using integrated avionics sensor flight data for the NASA ATOPS B-737 aircraft in a Microwave Landing System (MLS) environment. First, an overview of the FINDS algorithm structure is given. Then, aircraft state estimate time histories and statistics for the flight data sensors are discussed. This is followed by an explanation of modifications made to the detection and decision functions in FINDS to improve false alarm and failure detection performance. Next, the failure detection and false alarm performance of the FINDS algorithm are analyzed by injecting bias failures into fourteen sensor outputs over six repetitive runs of the five minutes of flight data. Results indicate that the detection speed, failure level estimation, and false alarm performance show a marked improvement over the previously reported simulation runs. In agreement with earlier results, detection speed is faster for filter measurement sensors such as MLS than for filter input sensors such as flight control accelerometers. Finally, the progress in modifications of the FINDS algorithm design to accommodate flight computer constraints is discussed. Author

**A86-11455#**

### ALGEBRAIC POLYNOMIAL APPROXIMATION IN THE LSQ SENSE OF A FAMILY OF CURVES

C. P. NEHRA (Allied/Bendix Aerospace Sector, Bendix Flight Systems Div., Teterboro, NJ) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 416-421.
(AIAA PAPER 85-6026)

An algorithm to derive an algebraic polynomial approximation in the LSQ sense for a family of curves generated by an n-dimensional function of form G(x,y,z...) is developed with reference to the design of embedded processor real-time systems. The algorithm has been used to approximate a family of curves representing: (1) the maximum range of an aircraft, which is a function of true air speed, altitude, and outside air temperature; and (2) damped sinusoids with the independent variables time, damping factor, and frequency. B.J.

**A86-11464#**

### ARCHITECTURAL CONCEPTS FOR INTEGRATED REALTIME MULTIPROCESSORS

G. W. GRUBE, W. W. SCALES, and D. P. WILLIAMS (AT&T Bell Laboratories, Whippany, NJ) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 474-477. refs
(AIAA PAPER 85-5053)

Methodology and architectural concepts at the system level for real-time microprocessor systems are examined with particular reference to multiprocessors for aerospace platforms. Data-flow multiprocessor architectures are illustrated by two examples, the Enhanced Modular Signal Processor and the AT&T Bell Laboratories' Data Flow Architecture. It is pointed out that the system architecture is strongly influenced by such nonfunctional requirements as reliability, fault tolerance, programmability, and modularity. V.L.

**A86-11535**
**FUNDAMENTAL ASPECTS OF THE THEORY OF CONTINUOUS MARKOVIAN CONTROLLABLE SYSTEMS AND THE APPLICATION OF THIS THEORY [OSNOVYE ASPEKTY TEORII NEPRERYVNYKH MARKOVSKIKH UPRAVLIAEMYKH SISTEM I EE PRILOZHENIE]**
V. K. BRUTIAN Yerevan, Izdatel'stvo Aiastan, 1984, 296 p. In Russian. refs

This monograph examines the theory of continuous stochastic automatic systems in the case of incomplete and imprecise information and significant parameter variations. Mathematical methods for the analysis and synthesis of Markovian controllable systems are developed in the framework of dynamic programming. The primary applications discussed pertain to the field of aviation; various problems of motion control for flight vehicles are examined, including the synthesis of an optimal autopilot and the angular stabilization of a flight vehicle. B.J.

**A86-11597**
**STRUCTURAL IDENTIFICATION OF LINEAR TIME-INVARIANT DYNAMIC SYSTEMS UNDER RANDOM INPUTS [STRUKTURNAIA IDENTIFIKATSIIA LINEINYKH STATSIONARNYKH DINAMICHESKIKH SISTEM PRI SLUCHAINYKH VOZDEISTVIIAKH]**
V. N. AZARSKOV, L. N. BLOKHIN, and A. A. TUNIK (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) Elektronnoe Modelirovanie (ISSN 0204-3572), vol. 7, Sept.-Oct. 1985, p. 39-42. In Russian.

An algorithm is developed which uses experimental data to obtain optimal estimates of the dynamic characteristics of a complex system and the random inputs acting on this system under regular operating conditions. This algorithm can be used for the identification of the dynamic characteristics of a passenger aircraft during automatic landing descent. B.J.

**N86-10831#** Air Command and Staff Coll., Maxwell AFB, Ala.
**LET'S GET SERIOUS ABOUT SOFTWARE**
J. R. HEGLAND Apr. 1985 47 p
(AD-A156819; ACSC-85-1130) Avail: NTIS HC A03/MF A01 CSCL 09B

This guide translates applicable Air Force and TAC data processing requirements into language and examples fighter crews can relate to and understand. It provides information on methods of programming, documenting, and submitting software to TAC. It is designed to help get fighter squadron software into TAC-wide distribution and prevent wasted efforts. Author (GRA)

**N86-10900#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
**GENERATION OF FLIGHT PATHS USING HIERARCHICAL PLANNING M.S. Thesis**
K. B. KLINE 1985 265 p
(AD-A156905; AFIT/CI/NR-85-37T) Avail: NTIS HC A12/MF A01 CSCL 12B

This thesis examines the use of an artificial intelligence technique, hierarchical planning, to solve the problem of generating an aircraft route and finding a path through various hostile environments. A route or path is evaluated by the number and type of threats the aircraft encounters on the route and the route length. An algorithm using hierarchical planning is presented and tested against several hostile environments. Specifically, the algorithms will divide the problem space or grid into smaller spaces or boxes. These boxes are then assigned values based upon the input hostile environment. Block paths are then constructed and evaluated based on the values in the boxes. An exhaustive search is performed on the two best block paths to find a flight path for the aircraft. Test results are compared to previous results obtained using heuristic search and indicate an improvement in solution quality. Although specific plans are incorporated into the algorithm to obtain test results, many other plans within the realm of hierarchical planning certainly exist and could be used to solve this problem. GRA

**N86-11857#** Air Command and Staff Coll., Maxwell AFB, Ala.
**A COMPUTER ENGINEERING CURRICULUM FOR THE AIR FORCE ACADEMY: AN IMPLEMENTATION PLAN**
L. L. BURGE, JR. Apr. 1985 113 p
(AD-A156464; ACSC-85-0335) Avail: NTIS HC A06/MF A01 CSCL 05I

The recent advances in computer technology which impact present and future Air Force systems led the Air Force Academy to include computers and information systems engineering courses in the curriculum. This analysis addresses the issue of a major in computer engineering at the Academy. The Air Force computer engineer (AFSCs 2625, 2736 and 2885) specializes in designing, developing, installing, and testing embedded computer systems in aircraft, missiles, flight simulators, and command, control, and communications systems. An embedded computer system is all computer equipment, programs, data, documentation, personnel, and supplies integral to a defense system from the design, acquisition, or operations and support point of view. This report addresses the Air Force need for computer engineers, the need for the computer engineering major at the Academy, the appropriate department to administer the major, the structure of the degree, and the implementation of the discipline at the Academy. Author (GRA)

**N86-11898#** Lockheed-California Co., Burbank.
**KRASH85 USER'S GUIDE: INPUT/OUTPUT FORMAT Final Report, Jan. - Sep. 1984**
M. A. GAMON, G. WITTLIN, and W. L. LABARGE Jul. 1985 240 p refs
(Contract DTFA03-84-C-00004)
(FAA-CT-85-10; LR-30777) Avail: NTIS HC A11/MF A01

The input and output formats appropriate for the computer program KRASH 85 are presented. Features that are incorporated into KRASH85 include: (1) an improved plastic hinge moment algorithm; (2) gear-oleo metering pin coding; (3) load-interaction curves; (4) an expanded initial conditions subroutine (combined with NASTRAN); (5) a comprehensive energy balance; (6) center of gravity (c.g.) displacement, velocity, acceleration and force time histories; (7) revised vertical beam orientation coding; (8) provision to save data for post-process i.e., acceleration, mass location and forces; (9) provisions to input preprocessed data; (10) a corrected uncoupled KR curve unloading/reloading algorithm; (11) provisions to define a tire spring (remains normal to the ground plane); (12) provisions to number the masses to an arbitrary sequence; and (13) an option to compute section shear and moment distributions. Author

## 16

## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-10177**
**THE GENERATION OF NOISE IN IMPINGING VORTEX MOTION PAST A STEP**
A. T. CONLISK and D. VELEY (Ohio State University, Columbus) Physics of Fluids (ISSN 0031-9171), vol. 28, Oct. 1985, p. 3004-3012. Research supported by the Ohio State University. refs

The noise field generated by the motion of one, two, or several rectilinear vortices in an inviscid, irrotational mean flow past a step is considered for low Mach number. The streakline patterns of an impinging vortex are compared with flow visualization studies, and qualitative agreement between the present analytical results and the experiments is achieved. Both acoustic pressure and intensity are strong functions of the vortex motion near the step which, because of the complexity of the geometry, must be

computed numerically. Results for the acoustic pressure and intensity are presented for a variety of incident vortex arrays.
Author

**A86-12025#**
**HELICOPTER NOISE**
R. LEGENDRE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1984, p. 59-61.

The state of the art in predicting and modeling helicopter noise, its sources, components, magnitudes and dynamic characteristics, is assessed. Noise is not emitted by steady flow, and can be decomposed into noise and pseudo-noise. Account must be taken of pseudo-noise in considerations of passenger comfort. The evolution of vortices in the turbulent boundary layer, the turbulent wake and at the blade tips produces noise. The difficulty in predicting noise arises from the complex behavior of vortices, atmospheric processes which affect the noise during flight and interactions among noise effects of separate blades and the fuselage noise. Various experiments are suggested for deriving quantitative laws to improve noise prediction efforts. M.S.K.

**N86-10909** ESDU International Ltd., London (England).
**SUMMARY OF WORK ON JET NOISE PREDICTION**
R. F. LAMBERT Apr. 1985 38 p refs
(ESDU-BR-62636; ESDU-AN-3oB) Avail: ESDU

Design data for aircraft noise, which include the estimation of subsonic far-field jet mixing noise are presented. It is proposed to extend the existing far field jet mixing noise to supersonic jet velocity conditions. The theories which form the basis for jet exhaust noise prediction are summarized. Measured and predicted overall and spectrum noise levels are compared. The existing data item, the theoretical basis for extending the item into the supersonic jet velocity region, and comparison with jet noise predictions are assessed. E.A.K.

**N86-10920#** Sandia National Labs., Albuquerque, N. Mex.
**UNDERSTANDING AND IMPROVING ACOUSTIC TO SEISMIC COUPLING AS IT PERTAINS TO SANDIA'S HELICOPTER DETECTOR**
G. ELLIOTT and R. J. FOGLER 18 Mar. 1985 22 p
(Contract DE-AC04-76DP-00789)
(DE85-009440; SAND-85-0841C) Avail: NTIS HC A02/MF A01

The basic physics of the acoustic-to-seismic coupling phenomenon involved in the operation of a helicopter detector under development are reported. A series of tests were conducted near Albuquerque, New Mexico, investigating the coupling phenomenon using an impulsive noise source and two different helicopters. Results of the tests including the evaluation of a new microphone windscreen design are presented. DOE

**N86-11169#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. for Experimental Fluid Mechanics.
**AEROACOUSTIC WIND TUNNEL MEASUREMENTS ON PROPELLER NOISE**
F. R. GROSCHE and H. STIEWITT *In* AGARD Aerodyn. and Acoustics of Propellers 9 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

Model tests were conducted in a low speed wind tunnel to determine the sound radiation of 5 propellers with different blade designs including variations of thickness ratios, blade profiles, blade planforms and blade tip configurations. The diameter of the propellers was 0.9 m, the propeller speed was kept constant. The tip Mach number was M sub I = 0.66 and the helical tip Mach number varied between 0.66 and 0.69. The main objectives were to investigate the effects of blade geometry on near field and far field noise and to locate the dominant sound sources in the propeller plane, radiating to the observer, by means of a highly directional microphone system. The results include: (1) comparisons of noise spectra of different propeller configurations; (2) near field sound pressures as function of axial distance from the propeller plane; and (3) directivity of sound radiation from the moving blades.
Author

**N86-11171#** Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
**AN INVESTIGATION OF IN-FLIGHT NEAR-FIELD PROPELLER NOISE GENERATION AND TRANSMISSION**
H. BONNEAU, D. F. WILFORD, and L. K. WOOD *In* AGARD Aerodyn. and Acoustics of Propellers 12 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

In flight near field propeller noise measurements, made on a General Aviation turboprop aircraft, are reported for a range of propeller operating conditions, and are shown to be well defined and reproducible. Measurements have been made at 8 exterior microphones, 2 located on a wing mounted boom, and 6 embedded in, and flush with the aircraft fuselage. Interior noise levels are also presented. Measured propeller harmonic levels are compared to first principle calculations of near field noise, using a modified version of the Farassat computer program, in which the blade surface pressure is described using the known aerodynamic properties of the blade (NACA 16) airfoil sections. The first few; i.e., the dominant harmonic levels of propeller noise are shown to be well predicted, while higher harmonic levels are underpredicted. The transmission loss between exterior and interior noise levels is shown to be relatively constant for varying propeller operating conditions and at two different locations along the length of the fuselage. Interior noise levels are also shown for the aircraft in gliding flight at various forward velocities, with both engines at idle and propellers feathered. A method of interpolating these measurements is discussed, which allows the interior noise due only to the forward velocity of the aircraft, to be determined. The transmission loss for this component is also discussed. Finally, interior noise levels are presented for a series of ground static tests with engine mounts of various different stiffnessses. B.W.

**N86-11172#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.
**FULL-SCALE FLIGHT AND MODEL-SCALE WIND TUNNEL TESTS ON THE NEARFIELD NOISE CHARACTERISTICS OF AIRCRAFT PROPELLERS**
H. HELLER, M. KALLERGIS, and B. GEHLHAR *In* AGARD Aerodyn. and Acoustics of Propellers 17 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

Flight noise tests employing a single engine Cessna T 207 aircraft with an array of wing mounted microphones were conducted to investigate nearfield acoustic characteristics of a 3 blade variable pitch propeller under different operational conditions, varying helical blade tip Mach number, propeller advance ratio, and blade loading. A special technique to minimize the engine exhaust influence on the propeller signature had been developed for this purpose. Supplementary, yet much more extensive tenth scale tests were performed in the DFVLR One Meter Acoustic Tunnel again in the acoustic nearfield of propellers with 2 to 6 blades over a substantial range or operational, partially interdependent, parameters, such as helical blade tip Mach number, blade pitch angle setting, blade incidence angle, rotational plane attitude, and ambient temperature. These data could also be compared to some third scale results for geometrically identical propellers. Especially the model tests allowed an exact quantification of the effect of the various parameters on the ensuing harmonic and subharmonic propeller noise spectra.
Author

**N86-11173#** Aeritalia S.p.A., Pomigliano D'Arco (Italy).
**CABIN NOISE REDUCTION FOR A NEW DEVELOPMENT TURBOPROP COMMUTER AIRCRAFT**
A. CARBONE, A. PAONESSA, L. LECCE (Ist. Progetto Velivoli, Naples), and F. MARULO (Ist. Progetto Velivoli, Naples) *In* AGARD Aerodyn. and Acoustics of Propellers 14 p Feb. 1985 refs
Avail: NTIS HC A20/MF A01

The program followed to attain an interior noise level similar to turbofan aircraft in a new design turboprop commuter is described. The need for an early consideration, in the definition phase of the aircraft, of the acoustic requirement for configuration development is stressed, along with some peculiar characteristics of this program. After a brief presentation of features of the aircraft related to interior noise control, the analytical and experimental models developed in the course of program are discussed. Some of the results of the studies are presented, clarifying the impact that they have had on the configuration of the aircraft. The output of three structural analysis theoretical procedures is compared to experiments. Two of these procedures, the panel stringer periodic model, and a simplified FEM analysis, are found adequate to represent experimental findings. The cylindrical shell - frame model is found not representative of test results. Sidewall treatment performance is discussed, with reference to theoretical and experimental results. The noise reductions measured in a furnished fuselage are compared to data obtained without interior treatment. Future developments and recommendations for additional work are discussed. Author

**N86-11174#** Lockheed-California Co., Burbank.

**PROPELLER AIRCRAFT CABIN VIBRATION AND NOISE-EXCITATION, SOURCES, AND PATHS**

R. E. DONHAM, F. J. BALENA, E. Z. BOCHARY, and O. K. LIEHR *In* AGARD Aerodyn. and Acoustics of Propellers 14 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

The potential sources and paths by which the propeller produces structural responses resulting in vibration and noise in the cabin of a transport aircraft are discussed. New low cost, convenient experimental and analytical techniques are described for evaluating the excitations; propeller airborne pressures on the fuselage shells, slip stream induced forces on the wing and tail, and oscillatory forces on the propeller. The techniques described make use of ground determined structural signatures to relate forces with vibrations or noise, and of propeller signatures from flight which define the vibroacoustic contributions of individual propellers. Author

**N86-11175#** Hamilton Standard, Windsor Locks, Conn.

**THE STATE OF THE ART IN PROPFAN TURBOPROP NOISE**

F. B. METZGER *In* AGARD Aerodyn. and Acoustics of Propellers 20 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

The evolution of propeller noise research is summarized from 1919 to the present. The early experimental and analytical work to understand and predict propeller noise is discussed. Emphasis is placed on understanding source noise. However, the major advances in cabin comfort assessment and design of airplane fuselage and cabin trim to improve passenger comfort are briefly described. Emphasis is on the recent noise research work on the propfan, a many bladed relatively small diameter unshrouded motor with swept blades that will allow future transports to cruise efficiently at speeds equal to modern turbofan transports. The most recent propfan concept, a counter rotation version with even greater efficiency potential than the propfan with a single blade row is also discussed. Author

**N86-11176#** Lockheed-Georgia Co., Marietta.

**APPLICATION OF ACTIVE NOISE CONTROL TO MODEL PROPELLER NOISE**

M. SALIKUDDIN, H. K. TANNA, R. H. BURRIN, and W. E. CARTER *In* AGARD Aerodyn. and Acoustics of Propellers 15 p Feb. 1985 refs

Avail: NTIS HC A20/MF A01

The applicability of active noise control to reduce cabin noise of turboprop aircraft is demonstrated by conducting several laboratory experiments. The principle of active noise control is to reduce the noise radiated from a primary source by superimposing a signal from a secondary source, which is made identical in amplitude but opposite in phase to the primary sound signal. A computer controlled algorithm was developed to implement this concept in a free field environment, in which, the noise from the primary source (eventually the propeller) and the noise measured at several locations on a representative surface (eventually the fuselage) were used to create the input for the secondary source. Experiments using a number of sinusoidal signals were conducted. An average noise reduction of 8 to 14 dB was achieved on the surface in the frequency range of 200 to 1000 Hz. Next the concept was applied to the propeller problem where the sound signal contains many discrete tones at harmonics of the blade passage frequency. For this purpose, a prerecorded time history of a 1/10th scale model propeller was used to drive the primary source. An average noise reduction of about 15 dB was observed at the first two blade passage frequencies, and 12 dB and 5 dB reductions were observed at the 3rd and 4th blade passage frequencies, respectively. Finally, the active noise control concept was applied to a 1/10th scale propeller, installed in an anechoic chamber with flight simulation facility. A substantial amount of noise reduction was achieved on the model fuselage surface. Author

**N86-12011*#** Texas A&M Univ., College Station. Dept. of Aerospace Engineering.

**A NUMERICAL METHOD OF CALCULATING PROPELLER NOISE INCLUDING ACOUSTIC NONLINEAR EFFECTS Abstract Only**

K. D. KORKAN *In* NASA. Lewis Research Center Numerical Tech. in Acoustics p 9-10 Oct. 1985 refs

(Contract NAG3-354)

Avail: NTIS HC A03/MF A01 CSCL 20A

Using the transonic flow fields(s) generated by the NASPROP-E computer code for an eight blade SR3-series propeller, a theoretical method is investigated to calculate the total noise values and frequency content in the acoustic near and far field without using the Ffowcs Williams - Hawkings equation. The flow field is numerically generated using an implicit three dimensional Euler equation solver in weak conservation law form. Numerical damping is required by the differencing method for stability in three dimensions, and the influence of the damping on the calculated acoustic values is investigated. The acoustic near field is solved by integrating with respect to time the pressure oscillations induced at a stationary observer location. The acoustic far field is calculated from the near field primitive variables as generated by NASPROP-E computer code using a method involving a perturbation velocity potential as suggested by Hawkings in the calculation of the acoustic pressure time-history at a specified far field observed location. the methodologies described are valid for calculating total noise levels and are applicable to any propeller geometry for which a flow field solution is available. Author

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-10274**

**THE BRAZILIAN AIRCRAFT INDUSTRY AND THE USE OF LAW AS A TOOL FOR DEVELOPMENT**

B. M. CARL (Southern Methodist University, Dallas, TX) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 50, no. 3-4, 1985, p. 513-586. Research supported by the Dana Foundation. refs

The innovative legal structure of Brazil's aircraft industry is discussed. The capitalizing of that industry though the mixed economy corporation and special techniques for marketing private shares are described, and the effect of these capital formation techniques are addressed. The production of Brazilian aircraft and the technology involved are discussed. The development of markets for the aircraft is addressed, including export incentives, and the relevance of these incentives for GATT rules and United States law is considered. C.D.

**A86-10937#**
**TEACHING AND LEARNING CONCEPTUAL DESIGN IN THE CAD ERA GENERATING PROBLEMS AND INTEGRATING SOLUTIONS**
E. TORENBEEK (DELFT, Technische Hogeschool, Netherlands) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 7 p. refs
(AIAA PAPER 85-3081)

Although universities are generally lagging behind the industry in adaptation of CAD techniques in preliminary aircraft design, they realize that changes in teaching methods are necessary. The paper describes a program undertaken at the Delft University of Technology to generate a pilot system for interactive computer-assisted conceptual aircraft design. A description is presented of the approach in designing the various major components of this system: geometry development, overall optimization and executive system, design analysis modules and technology data collection. Author

**A86-10959#**
**GENERAL AVIATION COST EFFECTIVENESS**
R. E. ETHERINGTON (Gates Learjet Corp., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 6 p.
(AIAA PAPER 85-4029)

The General Aviation Industry has not recovered from the last economic recession in the robust manner of the industry's recovery in the 1970 time frame. Indeed, the recovery in the 1970's was so strong that the middle seventies slow down was hardly noticed. The General Aviation Industry has not recovered from the major recession of the early eighties as have the other major industries. This paper examines cost effectiveness of the General Aviation Aircraft and postulates a loss of cost effectiveness as one possible reason for the lack of recovery. A cursory look at the cost effectiveness of the aircraft in the early 70's versus the early 80's reveals a dramatic reduction in productivity represented by the index of cost per pound-mile of payload range. This reduction is well in excess of the inflation rate. This paper examines in some limited detail the causes of this loss in cost effectiveness. Author

**A86-10972**
**COST AND SCHEDULE IMPLICATIONS OF MULTINATIONAL COPRODUCTION**
M. D. RICH, W. L. STANLEY, and J. L. BIRKLER (Rand Corp., Santa Monica, CA) SAE, Aerospace Vehicle Requirements Conference, Washington, DC, May 20-23, 1985. 7 p.
(SAE PAPER 851150)

The feasibility of multinational collaboration in connection with the acquisition of tactical weapon systems is being considered by both the United States and its European allies. Reasons for an interest in such a collaboration are related to the ever-rising cost of developing and producing weapon systems, a desire to standardize weapon systems used by North Atlantic Treaty Organization nations, a desire on the part of European members to improve their defense industrial capabilities, requirements for an equitable balance of defense hardware trade, and the growing number of European firms with suitable technical capacities. Taking into account, as an example, the F-16 fighter aircraft program, an analysis is conducted to assess the impact of coproduction on acquisition costs and schedules. It is found that European prices are competitive with U.S. prices for only about one-third of the part sets considered in a sample. Some guidelines are provided for lessening the inherent difficulties of collaboration. G.R.

**N86-11089#** National Aerospace Lab., Amsterdam (Netherlands).
**AEROSPACE RESEARCH AT NLR**
1984 39 p Original contains color illustrations
Avail: NTIS HC A03/MF A01

The NLR fluid dynamics, flight, structures and materials, space, and engineering and technical services divisions activities are presented. Research covers wind tunnel tests, computational aerodynamics, unsteady aerodynamics, aeroacoustics, propulsion systems, flight tests, aircraft performance assessment, human factors engineering, aircraft structures, aircraft loads, fatigue and corrosion, engine tests, satellite attitude control and ground operations, microgravity effects, robotics, and signal processing. Author (ESA)

**N86-12158*#** National Academy of Sciences - National Research Council, Washington, D. C.
**NASA-UNIVERSITIES RELATIONSHIPS IN AERO/SPACE ENGINEERING: A REVIEW OF NASA'S PROGRAM**
1985 33 p refs
(NASA-CR-176307; NAS 1.26:176307) Avail: NTIS HC A03/MF A01 CSCL 05I

NASA is concerned about the health of aerospace engineering departments at U.S. universities. The number of advanced degrees in aerospace engineering has declined. There is concern that universities' facilities, research equipment, and instrumentation may be aging or outmoded and therefore affect the quality of research and education. NASA requested that the National Research Council's Aeronautics and Space Engineering Board (ASEB) review NASA's support of universities and make recommendations to improve the program's effectiveness. G.L.C.

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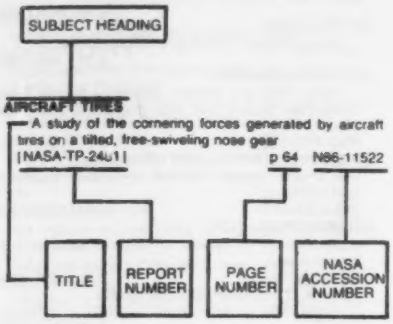

The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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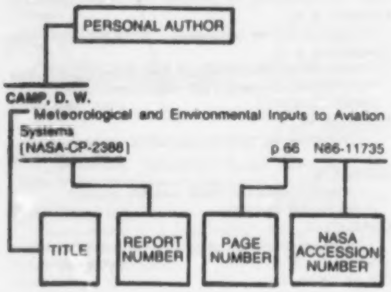

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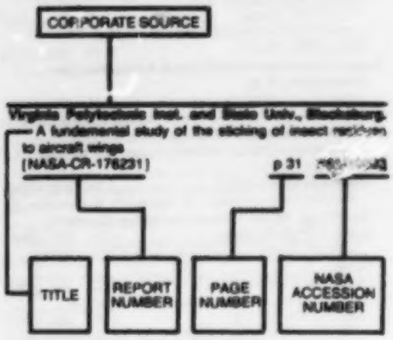
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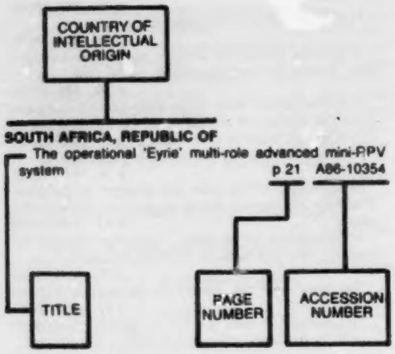
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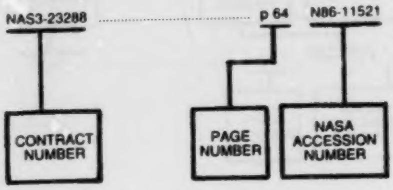

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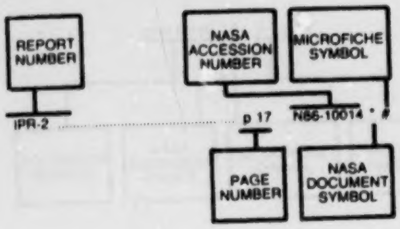

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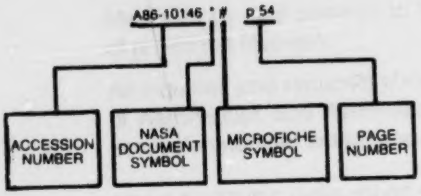

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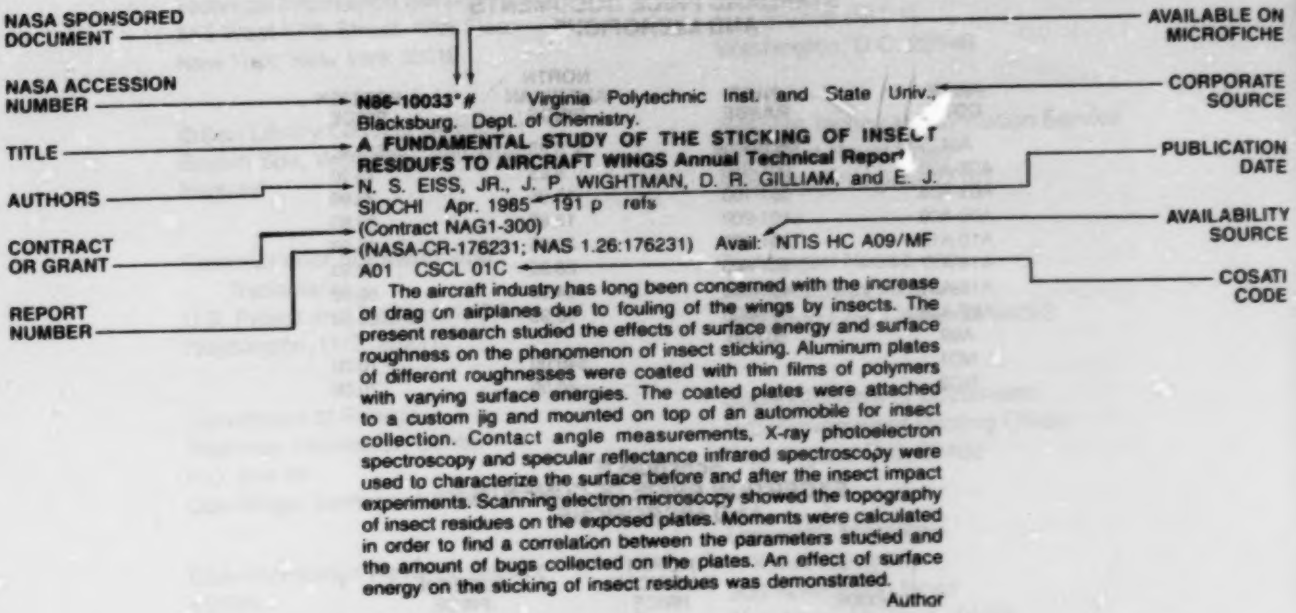
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**N86-10033*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.

**A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**

N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs

(Contract NAG1-300)

(NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

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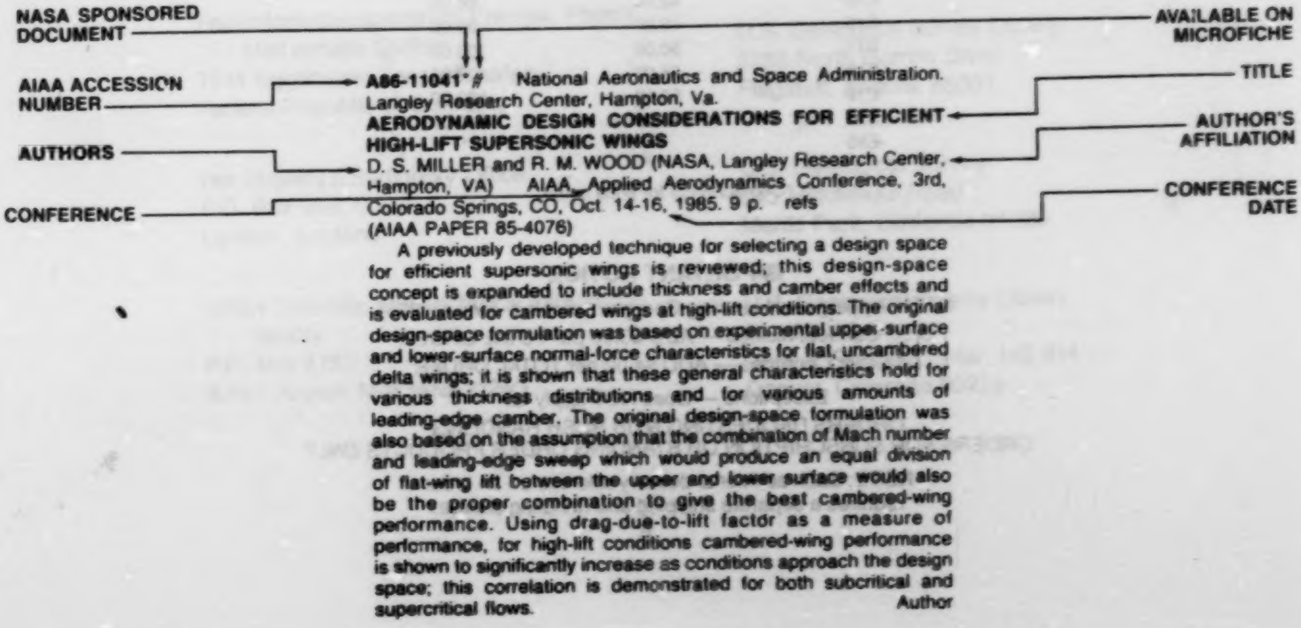
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**A86-11041*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS**

D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs

(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

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NASA SP-7037(198)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

## (Supplement 198)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in February 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 395 reports, journal articles, and other documents originally announced in February 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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# AERONAUTICAL ENGINEERING

## A Continuing Bibliography (Suppl. 198)

MARCH 1986

## 01

## AERONAUTICS (GENERAL)

**A86-13446**

**TECHNOLOGICAL SUPPORT FOR AIRCRAFT PRODUCTION [TEKHNOLOGICHESKAIA PODGOTOVKA AVIATSIONNOGO PROIZVODSTVA]**

V. N. KRYSIN Moscow, Izdatel'stvo Mashinostroenie, 1984, 200 p. In Russian. refs

The organization of technological support for aircraft production is reviewed with particular reference to the development of new equipment and processes to reduce the time required for setting up aircraft production. The discussion covers the fundamentals of technological support planning, standardization of equipment and processes, computer-aided design of manufacturing processes, automation of software development for digitally controlled machine tools, and the use of laser technology in installing assembly lines. Other topics discussed include equipment for the fabrication of composite structures, the manufacture of large components from high-strength titanium alloy sheets, and the use of manipulators and industrial robots. V.L.

**A86-13549**

**MANUFACTURERS PREPARE FOR EUROPE'S NEW FIGHTERS**

B. WANSTALL Interavia (ISSN 0020-5168), vol. 40, Oct. 1985, p. 1133-1136.

Carbon, boron, and Kevlar fiber-reinforced polymer matrix composites are being extensively employed in the French 'Rafale' ground attack aircraft and the British-German-Italian-Spanish 'European Fighter Aircraft' (EFA) interceptor. Al-Li alloys are also under consideration, subject to their development to the required levels of economy. Attention is presently given to the similarities and differences that have become evident to date in the Rafale and EFA development programs, which are scheduled to result in maiden flights in 1986. Full authority digital fly-by-wire systems will be used by both aircraft, and are noted to be the basis of significant weight savings through lift and control surfaces' area reduction. Single crewmember operation will be achieved through advanced cockpit display and controller electronics. O.C.

**A86-15285**

**THE AUTONOMOUS HELICOPTER SYSTEM**

J. F. GILMORE (Georgia Institute of Technology, Atlanta) IN: Applications of artificial intelligence; Proceedings of the Meeting, Arlington, VA, May 3, 4, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 146-152. refs

This paper describes an autonomous airborne vehicle being developed at the Georgia Tech Engineering Experiment Station. The Autonomous Helicopter System (AHS) is a multimission system consisting of three distinct sections: vision, planning and control. Vision provides the local and global scene analysis which is symbolically represented and passed to planning as the initial route planning constraints. Planning generates a task dependent path for the vehicle to traverse which assures maximum mission system success as well as safety. Control validates the path and either executes the given route or feeds back to previous sections in order to resolve conflicts. Author

**A86-15341**

**EC-135 FIBER OPTIC TECHNOLOGY REVIEW**

J. R. SCHULTZ and H. N. HODGES (TRW, Inc., Engineering Office, Albuquerque, NM) IN: Fiber optics in adverse environments II; Proceedings of the Meeting, San Diego, CA, August 22-24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 70-76. refs

(Contract DAEA18-81-G-0068)

The present paper is concerned with a fiber optic technology study for EC-135 Airborne Command Post aircraft application. This study had the objective to determine the feasibility of using fiber optic technology on the EC-135. Advantages of fiber optic technology over conventional technology are related to cost and weight savings, EMP and EMI immunity, electromagnetic compatibility, high data rates, and improved hardness maintenance. The motivation for this study was provided by the possibility that fiber optic technology could reduce the hardness maintenance difficulties for nuclear hardened EC-135 systems. Attention is given to the nuclear threat to the EC-135, aspects of nuclear hardening, and the reasons for considering fiber optic technology. G.R.

**A86-15600**

**DAMAGED RUNWAY OPTIONS EXPLORED**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Nov. 1985, p. 28-32.

A comparative evaluation is conducted of several concepts that have been proposed for the facilitation of aircraft takeoffs and landings on damaged airfields. Two of these rely on the air cushion effect: one, already implemented and tested in the 1970s on a Buffalo cargo aircraft, integrates the hovercraft-like inflatable hardware directly with the aircraft fuselage, while the other, still undergoing conceptual development, is a separate structure employed for takeoffs exclusively. Two other alternatives involve tank tread-like landing gears for landing and 'ski-jump' ramps for takeoff. The latter has been tested for the case of F/A-18 aircraft. O.C.

**A86-16096**

**ARMY VTOL RESEARCH AND DEVELOPMENT - THE FIRST CENTURY**

R. B. LEWIS, II (ITT Corp., Defense Space Group, Nutley, NJ) Vertiflite (ISSN 0042-4455), vol. 31, Nov.-Dec. 1985, p. 34-38.

The U.S. Army first expressed interest in VTOL aircraft in the form of balloons during the Civil War. Active engineering studies of helicopters began in 1918 and the first helicopter flight was recorded in 1922. Autorotation and mechanical cyclic pitch were demonstrated in 1923 and Congressional approval of development funds was obtained in 1938. The first Sikorsky helicopter was commissioned in 1939 and featured four rotors, one the main lifting rotor. Cyclic blade pitch eliminated two of the rotors. The Army retained responsibility for helicopter development after the Air Force was established, and by 1956 also gained procurement specifications authority, which led to a large order for OH-6A four-blade light observation helicopters in 1964. The LHX is the

next design goal for the Army and the helicopter industry.
M.S.K.

**N86-12199#** Aeronautical Research Labs., Melbourne (Australia).
**A SURVEY OF AERONAUTICAL STRUCTURAL RESEARCH IN AUSTRALIA**
F. H. HOOKE Dec. 1984 45 p
(AD-A157211; ARL/STRUC-TM-394) Avail: NTIS HC A03/MF A01 CSCL 01C

A survey of Aeronautical structural research in Australia has spanned over more than 40 years, from the establishment of the C.S.I.R. Division of Aeronautics in 1939. Industry, civil aviation and the armed services have benefited from the expertise of Structures Division in problem solving, as well as from ad-hoc research and, perhaps less immediately, from basic research. Not every avenue has been able to be explored. A major subject of research, structural fatigue, arose from an accident in 1945, and each new development in design and material has brought new problems. Standards of safety and risk have been explored. New technology of fiber composites permits better tailoring of strength and stiffness to requirements: this and the introduction to aircraft of active controls offer benefits and problems for the future.
Author (GRA)

**N86-12200#** Air Force Academy, Colo.
**AIR FORCE ACADEMY AERONAUTICS DIGEST Final Report**
J. E. DEJONGH, W. H. HEISER, and M. HALE Apr. 1985 269 p
(AD-A157215; USAFA-TR-85-2) Avail: NTIS HC A12/MF A01 CSCL 20D

Some articles of the digest are entitled: The Seven-Hole Pressure Probe; Wind Tunnel Study on the Drag Effects of an Aft-Mounted Ventral Fin on a T-38 Model; An Experimental Investigation of an Airfoil Undergoing Large Amplitude Pitching Motions; Interrelated Effects of Pitch Rate and Pivot Point on Airfoil Dynamic Stall. Other topics covered are: An Examination of Curve Smoothing Using Digital Filter Theory; Flight Test Measurement of the Aerodynamic Effect of Thrust Level on Lift and Drag; and Flight Control System Design for a Computer Controlled Aircraft with Limited Sensors.
GRA

**N86-13266*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**ASSESSMENT OF AERODYNAMIC AND DYNAMIC MODELS IN A COMPREHENSIVE ANALYSIS**
W. JOHNSON Oct. 1985 39 p refs
(NASA-TM-86835; REPT-85047; NAS 1.15:86835) Avail: NTIS HC A03/MF A01 CSCL 01B

The history, status, and lessons of a comprehensive analysis for rotorcraft are reviewed. The development, features, and capabilities of the analysis are summarized, including the aerodynamic and dynamic models that were used. Examples of correlation of the computational results with experimental data are given, extensions of the analysis for research in several topics of helicopter technology are discussed, and the experiences of outside users are summarized. Finally, the required capabilities and approach for the next comprehensive analysis are described.
Author

**N86-13618#** Joint Publications Research Service, Arlington, Va.
**ATR 42 PRODUCTION WORK IN FRENCH, ITALIAN PLANTS DETAILED**
*In its* West Europe Rept.: Sci. and Technol. (JPRS-WST-85-031) p 14-19 8 Nov. 1985 Repr. from Rev. Aerospatiale (France), Oct. 1985 p 16; 18; 20; 22; 27
Avail: NTIS HC A03/MF A01

The ATR-42 passenger aircraft is to be a product of real international cooperation. The Franco-Italian aircraft is to be produced and assembled at three plants in France and one in Italy, with engines supplied by Pratt and Whitney of Canada. The composite wing tips, control surfaces and fairings will be manufactured at Aerospatiale in Nantes. Assembly, integration, and testing of the wing are to be subsequently carried out at the Aerospatiale plant in Sainte Nazaire. The engine nacelles are to be produced by Aerospatiale Meaulte. Manufacturing the fuselage and tail assembly will be the responsibility of Aeritalia in Naples, and final assembly will take place at Aerospatiale's Toulouse plant. Production of the larger version, the ATR-72, will be similarly apportioned.
F.M.R.

# 02

# AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-13047**
**HYPERSONIC FLOW PAST NON-SLENDER WEDGES, CONES AND OGIVES IN OSCILLATION**
K. GHOSH (Indian Institute of Technology, Kanpur, India), M. VEMPATI, and D. DAS Aeronautical Journal (ISSN 0001-9240), vol. 89, Aug.-Sept. 1985, p. 247-256. refs

Ghosh's (1977) large-deflection hypersonic similitude and consequent plane and conico annular piston theories have been applied to obtain unsteady pressure and the pitching moment derivatives for oscillating nonslender wedges, cones and ogives. The plane piston theory for a wedge is extended from a quasi-steady analysis, which gives the moment derivative due to pitch rate Cm(q), to an unsteady analysis; the two analyses combine to give the moment derivative due to incidence rate CM (alpha), which is shown here to be the same for wedges and quasi-wedges. The present theory can separately give Cm(q) and CM(alpha) for a quasi-wedge of arbitrary shape; this principle is illustrated for a particular quasi-wedge, namely the parabolic arc plane ogive. In comparison, a previous theory by Hui (1969) gave only the sum of Cm(q) and Cm(theta), only for wedges. The conico annular piston theory is employed to obtain Cm(theta), which is the moment derivative due to a steady pitch angle, and Cm(q) for nonslender cones and axisymmetric ogives in closed form for the first time.
Author

**A86-13050**
**AERODYNAMICS - THE ROLE OF THE COMPUTER**
G. J. HANCOCK (Queen Mary College, London, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Aug.-Sept. 1985, p. 269-279. refs

The use of computers in aerospace aerodynamics is reviewed. Computational aerodynamics has advanced due to increasing computer speeds, growth in memory capabilities, and architectural improvements. Numerical modelling of physical flows, algorithm development, research and production code development, and evaluation and validation of the codes using computational aerodynamics are described and examples are provided. The application of computational aerodynamics in aerodynamic design is discussed. In experimental aerodynamics computers are useful in rig automation, data acquistion and synthesis, the design of test facilities, and the specification of test procedures. The interaction between control systems and aerodynamics is studied. The extraction of aerodynamic information from flight tests with computers is discussed.
I.F.

**A86-13060#**
**NUMERICAL ANALYSIS OF FULLY THREE-DIMENSIONAL PERIODIC FLOWS THROUGH A TURBINE STAGE**
M. KOYA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) and S. KOTAKE (Tokyo, University, Japan) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 945-952. refs
(ASME PAPER 85-GT-57)

Fully three-dimensional periodic flows through a turbine stage of stator and rotor are studied numerically by solving time-dependent three-dimensional Euler equations with the finite-volume method. The phase relation of stator and rotor flows and the related blade-row interaction are accounted for in the time-space domain. The established method of numerical calculation makes a practical contribution to predict actual turbine flows through a turbine stage of stator and rotor which have an arbitrary number of blades. Author

**A86-13062#**

### SECONDARY FLOWS AND LOSSES DOWNSTREAM OF A TURBINE CASCADE

J. MOORE and R. Y. ADHYE (Virginia Polytechnic Institute and State University, Blacksburg) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 961-968. Research supported by the Rolls-Royce, Ltd. refs
(ASME PAPER 85-GT-64)

The loss mechanisms and the behavior of secondary flows downstream of a large scale, linear turbine cascade have been investigated experimentally. A five-blade replica of the cascade used by Langston et al. at United Technologies Research Center was used for the present tests. Detailed flow measurements, using five-hole and three-hole probes, were made at four different planes, one just upstream of the trailing edge and the rest downstream. The secondary flow field at each measurement plane was found to be dominated by a single large passage vortex, which decayed in strength because of the mixing occurring in the flow. More than one-third of the losses were found to occur downstream of the trailing edge. This rise in total pressure loss in the present tests was almost entirely explained by a corresponding dissipation of the secondary kinetic energy of the flow. A mixing analysis of the flow was done to predict the additional losses due to 'mixing' until the flow became completely uniform. Author

**A86-13063#**

### PERFORMANCE EVALUATION OF LINEAR TURBINE CASCADES USING THREE-DIMENSIONAL VISCOUS FLOW CALCULATIONS

J. MOORE and J. G. MOORE (Virginia Polytechnic Institute and State University, Blacksburg) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 969-975. Research supported by the Rolls-Royce, Ltd. refs
(ASME PAPER 85-G-65)

The overall performance of two geometrically similar linear turbine cascades is calculated using an elliptic flow program. The increase in the mass-averaged total pressure loss is calculated within and downstream of the cascades and the results show good agreement with the measured values. The buildup and decay of the secondary kinetic energy are also shown; measurements are available for one of the cascades near and downstream of the trailing edge and these are in close agreement with the calculated values. Details of the flow development are also compared with measurements. Calculated velocity vectors near the endwall show the overturning revealed by surface flow visualization and similarly near the suction surface the strong spanwise flow is well calculated. Calculated contours of total pressure loss in cross-sectional planes confirm the important interaction of the passage vortex with the profile boundary layer at midspan. Regions of high loss near midspan are calculated downstream of both cascades; this three-dimensional flow development is followed in the calculations. Author

**A86-13065#**

### EFFECTS OF TIP ENDWALL CONTOURING ON THE THREE-DIMENSIONAL FLOW FIELD IN AN ANNULAR TURBINE NOZZLE GUIDE VANE. I - EXPERIMENTAL INVESTIGATION

E. BOLETIS (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 983-990. refs
(ASME PAPER 85-GT-71)

Tip endwall contouring is one of the most effective methods for improving the performance of low aspect ratio turbine vanes. In view of the wide variety of geometric parameters, it appears that only the physical understanding of the three-dimensional flow field will allow evaluation of the probable benefits of a particular endwall contouring. The paper describes the experimental investigation of the three-dimensional flow through a low speed, low aspect ratio, high turning annular turbine nozzle guide vane with meridional tip endwall contouring. The full impact of the effects of tip contouring is evaluated by comparison with the results of a previous study in an annular turbine nozzle guide vane of the same blade and cascade geometry with cylindrical endwalls. In parallel, the present experimental study provides a fully three-dimensional test case for comparison with advanced theoretical calculation methods. The flow is explored by means of double-head, four-hole pressure probes in five axial planes from far upstream to downstream of the blade row. The results are presented in the form of contour plots and spanwise pitch-averaged distributions. Author

**A86-13067#**

### SIMULATION OF THE EFFECTS OF SHOCK WAVE PASSING ON A TURBINE ROTOR BLADE

D. J. DOORLY and M. L. G. OLDFIELD (Oxford University, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 998-1006. Research supported by the Rolls-Royce, Ltd. and SERC. refs
(ASME PAPER 85-GT-112)

The unsteady effects of shock waves and wakes shed by the nozzle guide vane row on the flow over a downstream turbine rotor have been simulated in a transient cascade tunnel. At conditions representative of engine flow, both wakes and shock waves are shown to cause transient turbulent patches to develop in an otherwise laminar (suction-surface) boundary layer. The simulation technique employed, coupled with very high-frequency heat transfer and pressure measurements, and flow visualization, allowed the transition initiated by isolated wakes and shock waves to be studied in detail. On the profile tested, the comparatively weak shock waves considered do not produce significant effects by direct shock-boundary layer interaction. Instead, the shock initiates a leading edge separation, which subsequently collapses, leaving a turbulent patch that is convected downstream. Effects of combined wakeand shock wave-passing at high frequency are also reported. Author

**A86-13294**

### CALCULATION OF FLOWS IN TWO- AND THREE-DIMENSIONAL NOZZLES BY AN APPROXIMATE FACTORIZATION METHOD [RASCHET TECHENII V DVUMERNYKH I PROSTRANSTVENNYKH SOPLAKH METODOM PRIBLIZHENNOI FAKTORIZATSII]

M. IA. IVANOV and V. V. KORETSKII Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 25, Sept. 1985, p. 1365-1381. In Russian. refs

An efficient approximate factorization procedure has been developed for calculating steady-state mixed subsonic, transonic, and supersonic potential flows in two- and three-dimensional nozzles. The method is based on the numerical integration of the full equation for the velocity potential written in divergent form and provides a second order of approximation. The advantages of the approach proposed here over other approximate factorization and relaxation methods and finite-difference schemes are demonstrated. V.L.

**A86-13296**

**A MARCHING EXPLICIT-IMPLICIT PROCEDURE FOR CALCULATING SUPERSONIC FLOW PAST BODIES [MARSHEVYI IAVNO-NEIAVNYI METOD RASCHETA SVERKHZVUKOVOGO OBTEKANIIA TEL]**

N. V. POGORELOV and IU. D. SHEVELEV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 25, Sept. 1985, p. 1391-1400. In Russian. refs

A second-order hybrid, two-step, explicit-implicit finite difference scheme is applied to a marching procedure for calculating supersonic flow of an ideal gas past blunt bodies on the basis of a system of equations written in the form of conservation laws. Each step of the procedure consists of two half-steps; during the first half-step, a solution is sought using an explicit scheme with one-sided differences, while during the second half-step, the finite-difference equations are transformed to an implicit form. A bidiagonal block system of equations is solved at each implicit step; when the Courant condition is satisfied, the implicit steps automatically disappear, and the scheme becomes explicit. V.L.

**A86-13351**

**THE LINEAR THEORY OF A PROFILE IN A COMPRESSIBLE GAS WITH ADDITIONAL JET FLOW [LINEINAIA TEORIIA PROFILIA V SZHIMAEMOM GAZE PRI DOPOLNITEL'NOM OBDUVE STRUEI]**

G. A. PAVLOVETS TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 1-11. In Russian. refs

The problem of a profile in a compressible gas with additional compressed-gas jet flow is analyzed in the context of linear theory, and expressions are obtained for flow velocities at the jet boundaries and for the boundary shape. For an arbitrary profile, the problem is reduced to that of solving a singular integral equation. Expressions are presented which illustrate the effect of various parameters of the jet and external flow on the lifting force of the profile. It is shown that the problem of jet flow of an ideal compressible gas past a profile can be reduced to an identical problem for an ideal incompressible liquid with somewhat different flow parameters. V.L.

**A86-13352**

**SYMMETRIC TRANSONIC FLOW PAST WINGS OF LARGE ASPECT RATIOS [O SIMMETRICHNOM OBTEKANII TRANSZVUKOVYM POTOKOM KRYL'EV BOL'SHOGO UDLINENIIA]**

IU. B. LIFSHITS and A. M. SOROKIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 12-18. In Russian. refs

A study is made of the applicability of approximate similarity laws established through an analysis of the first terms of a potential expansion in a small parameter that is the reciprocal of the wing aspect ratio. For this purpose, symmetric flow past straight and swept wings is analyzed numerically for various free-stream Mach numbers, aspect ratios, and swep angles. The numerical data obtained, along with an analysis of the initial equations and equations for the terms of the asymptotic expansion, make it possible to determine the nature of the dependence of the aerodynamic characteristics on the problem parameters and also to explain a discrepancy between the numerical and analytical data. V.L.

**A86-13353**

**A STUDY OF FLOW NEAR A SHOCK WAVE INTERSECTION LINE [ISSLEDOVANIE TECHENIIA V OKRESTNOSTI LINII PERESECHENIIA SKACHKOV UPLOTNENIIA]**

V. V. KELDYSH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 19-30. In Russian. refs

An analysis is made of three-dimensional flow in the vicinity of the intersection of two shock waves. A region of changes in the governing parameters is identified where the problem has two solutions. For the region where the problem has only one solution, a solution to the problem of the intersection of three incoming shock waves exists. It is also shown that lambda-shaped shock waves are a particular case of the same problem, with one of the waves near the intersection line degenerated to a Mach wave. V.L.

**A86-13354**

**THE EFFECT OF THE INCALCULABLE FLOW REGIME OF AIR SCOOPS ON FLOW PAST A WING [VLIIANIE NERASCHETOROGO REZHIMA RABOTY VOZDUKHOZABORNIKOV NA OBTEKANIE KRYLA]**

B. G. PIANZIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 31-39. In Russian. refs

The problem of the effect of the incalculable flow regime of wing air scoops on flow past the wing is investigated in the context of the existing linear vortex theory of a profile and a wing with an air scoop (Shurygin, 1980, 1981). In particular, the effect of air scoop flow rate distribution on the aerodynamic characteristics of the wing is analyzed numerically. Numerical calculations for wings of different shapes and air scoops of different lengths provide qualitatively consistent results. V.L.

**A86-13358**

**SELECTING THE PRINCIPAL PARAMETERS OF A WEDGE-PROFILED WING [VYBOR OSNOVNYKH PARAMETROV KRYLA S LAMBDA-OBRAZNYM POPERECHNYM SECHENIEM]**

G. I. MAIKAPAR and A. I. PIATNOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 104-109. In Russian. refs

Graphs are presented for determining the aerodynamic characteristics of a wedge-profiled wing of a specified volume for supersonic velocities. The graphs provide a way to select the geometrical parameters of a wing with allowance for additional constraints. It is shown that for a length less than optimum, part of the volume should be located over the leeside of the wing, and an oblique section can be used to reduce the wake drag. V.L.

**A86-13359**

**AERODYNAMIC CHARACTERISTICS OF A FINITE-ASPECT-RATIO WING IN HYPERSONIC FLOW OF A RADIATING GAS [AERODINAMICHESKIE KHARAKTERISTIKI KRYLA KONECHNOGO RAZMAKHA V GIPERZVUKOVOM POTOKE IZLUCHAIUSHCHEGO GAZA]**

V. N. GOLUBKIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 115-120. In Russian. refs

The problem of hypersonic flow of a radiating gas past the windward side of a finite-aspect-ratio wing at large angles of attack is solved analytically to a first approximation using the method of a thin shock layer. The wing surface is nearly plane, its leading edge is sharp, and its shape varies with time. The effect of radiation on the shock wave shape, pressure distribution, and aerodynamic coefficients is examined. V.L.

**A86-13360**

**FLOW OF A DIATOMIC RAREFIED GAS AROUND A CONE [OBTEKANIE KONUSA DVUKHATOMNYM RAZREZHENNYM GAZOM]**

S. L. GORELOV and A. I. EROFEEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 125-128. In Russian. refs

The problem of hypersonic flow of a diatomic rarefied gas around a cone with half-angles of 10 and 15 deg is solved using the Monte Carlo method. Calculations are carried out for two values of the temperature factor, 1 and 0.1. The results obtained are compared with similar calculations for a monoatomic gas and with experimental data. V.L.

**A86-13363**

**SOME SOLUTIONS TO THE KARMAN EQUATION DESCRIBING FLOW PAST THE SALIENT POINTS OF A PROFILE [O NEKOTORYKH RESHENIIAKH URAVNENIIA KARMANA OPISYVAIUSHCHIKH OBTEKANIE TOCHEK IZLOMA PROFILIA]**

V. N. DIESPEROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 11-19. In Russian. refs

A solution to the Karman equation for flow past a salient point of a profile with a free flow line is obtained for the case where the subsonic generating line is specified by an arbitrary power law. Attention is also given to the case where the curvature of the subsonic generating line of the salient point is determined by the displacement thickness of the boundary layer during its interaction with the Vaglio-Laurin external potential flow. V.L.

**A86-13364**

**CALCULATION OF SUPERSONIC INVISCID FLOW PAST A PLANE AIR INTAKE ELEMENT WITH AN ISOLATED HEAD WAVE [RASCHET SVERKHZVUKOVOGO NEVIAZKOGO OBTEKANIIA ELEMENTA PLOSKOGO VOZDUKHOZABORNIKA S VYDELENNOI GOLOVNOI VOLNOI]**

S. M. BOSNIAKOV, V. V. KOVALENKO, and A. N. MINAILOS TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 20-29. In Russian. refs

A procedure for calculating supersonic flow past complex bodies is presented which uses a second-order finite difference scheme with nonuniform templates and head wave isolation. Numerical solutions are obtained for flow past a wedge-shaped air intake element and for its aerodynamic characteristics. The flow fields are analyzed, and the results are compared with experimental data and results obtained by using McCormack's first-order finite-difference scheme. V.L.

**A86-13373**

**A JOINT ANALYSIS OF THE BOUNDARY LAYER AND INVISCID FLOW AROUND THE AXISYMMETRIC REAR SECTION OF A FUSELAGE [SOVMESTNYI RASCHET POGRANICHNOGO SLOIA I NEVIAZKOGO POTOKA, OBTEKAIUSHCHEGO OSESIMMETRICHNUIU KORMOVUIU CHAST' FIUZELIAZHA]**

N. L. EFREMOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 119-124. In Russian. refs

Transonic flow past a body of the fuselage or engine nacelle type is analyzed, with allowance made for flow viscosity in terms of turbulent boundary layer theory. Inviscid flow is calculated using Godunov's finite difference scheme, and a joint solution is obtained by using an iteration procedure. To ensure the convergence of iterations, a relaxation (damping) procedure is used for calculating Mach number distributions at the inviscid flow boundary and the boundary layer displacement thickness on the basis of previous iterations. The approach proposed here is illustrated by an example. V.L.

**A86-13374**

**A NUMERICAL ANALYSIS OF THE CHARACTERISTICS OF A TOLLMIEN-SCHLICHTING WAVE PACKET IN A BOUNDARY LAYER ON A FLAT PLATE [CHISLENNYI ANALIZ KHARAKTERISTIK PAKETA VOLN TOLLMINA-SHLIKHTINGA V POGRANICHNOM SLOE NA PLOSKOI PLASTINE]**

A. M. TUMIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 125-127. In Russian. refs

The characteristics of Tollmien-Schlichting wave packets in a boundary layer on a flat plate are calculated for various Mach numbers using a software set developed for calculating the stability of boundary layers in a compressible gas. In all examples, the Prandtl number is 0.72, the stagnation temperature is 310 K, and the specific heat ratio is 1.41. An analysis of the results obtained shows that the development of instability waves in a packet differs substantially from the development of monochromatic perturbations. Results are presented in graphical form and compared with those obtained by the envelope method. V.L.

**A86-13375**

**PROFILING OF SUPERSONIC DUCTS WITH SPECIFIED NONISENTROPIC PARAMETERS AT THE EXIT [O PROFILIROVANII SVERKHZVUKOVYKH KANALOV S ZADANNYMI NEIZOENTROPICHESKIMI PARAMETRAMI NA VYKHODE]**

A. S. VOINOVSKII and V. I. KIREEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 128-133. In Russian. refs

Plane and axisymmetric supersonic ducts are profiled with a specified distribution of entropy or total pressure at the exit and also with specified Mach and velocity vector angle distributions at the exit and along the profiled duct walls. The specified entropy distribution at the exit is provided by a shock wave at the duct inlet. A duct is designed with Mach 3 at the inlet which ensures a compression and rotation of the flow to Mach 1.05 and a zero velocity vector angle, with varying entropy distributions at the exit. A plane supersonic duct is also designed which simulates vortex flow near the lateral surface of a blunt body in hypersonic flow. V.L.

**A86-13377**

**A NUMERICAL STUDY OF AXISYMMETRIC FLOW PAST A DISK [CHISLENNOE ISSLEDOVANIE OSESIMMETRICHNOGO OBTEKANIIA DISKA]**

V. I. MYSHENKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 139-144. In Russian. refs

The problem of axisymmetric flow of an ideal viscous heat-conducting gas past a disk is solved numerically using the Navier-Stokes equations for subsonic and supersonic flow velocities (Mach 0.5-3). The formation and evolution of separated flow in the near wake of the disk is investigated for various Mach and Reynolds numbers; changes in the geometrical and gasdynamic parameters of the separated zone are analyzed. Heat fluxes toward the disk surface are determined. V.L.

**A86-13379**

**A STUDY OF THE NORMAL OF A DELTA-WING AIRCRAFT AT LARGE ANGLES OF ATTAC[illegible]NG UNSTEADY MOTION [ISSLEDOVANIE NORMAL'N[illegible] SILY SAMOLETA S TREUGOL'NYM KRYLOM NA BOL'SHIKH UGLAKH ATAKI PRI NEUSTANOVIVSHEMSIA DVIZHENII]**

IU. A. VINOGRADOV, IU. B. DUBOV, A. N. ZHUK, V. P. MAMROV, and G. I. STOLIAROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 1-10. In Russian. refs

Results of an experimental study of the normal force of a model of a delta-wing aircraft during unsteady motion at subsonic speeds are reported for a wide range of angles of attack. It is shown that in the case of large angles of attack corresponding to unsteady separated flows, the aerodynamic forces differ essentially from those observed in steady flow. The results of the aerodynamic experiment are compared with flight test data. V.L.

**A86-13380**

**A COMBINED METHOD FOR THE ANALYSIS OF THE AERODYNAMIC FORCES ACTING ON AN OSCILLATING FLIGHT VEHICLE IN SUPERSONIC FLOW [KOMBINIROVANNYI METOD RASCHETA AERODINAMICHESKIKH SIL NA KOLEBLIUSHCHEMSIA LETATEL'NOM APPARATE S SVERKHZVUKOVOM POTOKE]**

V. G. BUNKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 11-22. In Russian. refs

Aerodynamic forces acting on the system wing-elevator unit in supersonic flow are calculated using the finite element approach. Both the wing and the elevator unit are analyzed using the velocity potential method as the most correct of the known linear methods, the interference between the wing and the elevator unit is analyzed using the acceleration potential method. It is shown that the substitution of a real potential for a complex potential significantly reduces the computation time (from 25 to 5 min for 160 nodes). Substantial savings in computer time and memory are also achieved by dividing the wing into sections with different type of solutions (zero, explicit, real, and complex). The application of the method to flutter analysis is illustrated by two straightforward examples. V.L.

**A86-13381**

### STATISTICAL FORMULATION OF THE OBJECTIVES OF THE AERODYNAMIC EXPERIMENT [STATISTICHESKAIA POSTANOVKA ZADACH AERODINAMICHESKOGO EKSPERIMENTA]

G. L. GRODZOVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 31-44. In Russian. refs

The principal objective of the aerodynamic experiment is formulated as determining functional relations between the mathematical expectations (and other statistical moments) of the real fluctuating aerodynamic characteristics. On the basis of experimental data on the repeatability of the mean characteristics of the aerodynamic experiment (with similarity criteria observed), the ergodicity principle is established for turbulent flows. It is shown that the finite duration of the aerodynamic experiment leads to errors in determinations of the mathematical expectation of fluctuating aerodynamic characteristics. An adaptive algorithm is proposed for conducting an aerodynamic experiment with a specified stochastic error in minimum time. V.L.

**A86-13389**

### CERTAIN CHARACTERISTICS OF PARACHUTE-WING AERODYNAMICS [NEKOTORYE OSOBENNOSTI AERODINAMIKI PARASHIUTA-KRYLA]

O. P. BRYSOV, E. P. EZEEVA, and IU. G. LIMONAD TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 121-126. In Russian.

The aerodynamic characteristics of parachute-wing models are investigated experimentally at subsonic speeds using the optical method. It is shown that the profile drag of parachutes of the wing type is a factor of 5-10 greater than that of the rigid wing of an aircraft. The probable causes of high profile drag of the parachute wing are examined; the effect of the permeability of the model shell is discussed. V.L.

**A86-13390**

### PROPAGATION OF SMALL PERTURBATIONS DURING THE INTERACTION OF NONVISCOUS JETS [RASPROSTRANENIE MALYKH VOZMUSHCHENII PRI VZAIMODEISTVII NEVIAZKIKH STRUI]

T. V. TITOVSKAIA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 127-131. In Russian. refs

The problem of the propagation of small perturbations during the interaction of subsonic and supersonic nonviscous plane jets in a duct with parallel walls is analyzed. The discrete spectra of the true and apparent eigenvalues and eigenfunctions corresponding to the exponentially attenuated and nonattenuated small perturbations are determined numerically. The absence of complex solutions is demonstrated analytically. V.L.

**A86-13391**

### THE EFFECT OF THE BLUNTNESS AND THE HALF-ANGLE OF A CONE ON THE TURBULENT TRANSITION OF A BOUNDARY LAYER AT FREE-STREAM MACH 6 [VLIIANIE ZATUPLENIIA I POLUUGLA RASTVORA KONUSA NA PEREKHOD LAMINARNOGO POGRANICHNOGO SLOIA V TURBULENTNYI PRI CHISLE MACH 6]

A. R. IVANOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 132-135. In Russian.

Experimental data are presented on the effect of the half-angle and bluntness of a cone model on the location of the turbulent transition of the boundary layer at free-stream Mach 6, Re = 2.8 x 10 to the 6th for large angles of attack. It is shown that the bluntness of the model delays the turbulent transition; an increase in the cone half-angle accelerates the transition. On a blunted cone, separated flow is formed at smaller angles of attack than on a sharp cone. V.L.

**A86-13392**

### A METHOD FOR MEASURING THE DIRECTION AND THE MACH NUMBER OF A THREE-DIMENSIONAL SUPERSONIC NOZZLE [K METODIKE IZMERENIIA NAPRAVLENIIA I CHISLA M TREKHMERNOGO SVERKHZVUKOVOGO POTOKA]

M. D. BRODETSKII, G. P. OLKHOVIKOV, A. M. KHARITONOV, A. M. SHEVCHENKO, and S. I. SHPAK TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 136-139. In Russian. refs

A pneumometric technique using five-channel pneumatic nozzles is proposed for the simultaneous measurement of the direction, the Mach number, and the full pressure. The pneumatic nozzles have been calibrated with respect to the pitch and roll angles in the Mach range 2.03-4.05, and a mathematical model of a five-channel pneumatic nozzle has been developed on the basis of the calibration results. Test results for a wedge and a delta-wing model indicate that the angles are determined with an accuracy to within 1 degree and mach numbers to within 4 percent. V.L.

**A86-13395**

### AN ANALYSIS OF SEPARATED FLOW OF AN IDEAL FLUID PAST A FINITE-ASPECT-RATIO MECHANIZED WING [RASCHET OTRYVNOGO OBTEKANIIA MEKHANIZIROVANNOGO KRYLA KONECHNOGO UDLINENIIA POTOKOM IDEAL'NOI ZHIDKOSTI]

G. G. SUDAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 1-6. In Russian. refs

The problem of separated flow of an ideal fluid past a finite-aspect-ratio mechanized wing is solved numerically using the method of matched asymptotic expansions. As an example, aerodynamic characteristics are calculated for a rectangular wing in the presence of separation from the lateral edges. Results are presented in graphical form. V.L.

**A86-13396**

### CONSTRUCTION OF EQUIVALENT PROFILES AND APPROXIMATE CALCULATION OF TRANSONIC FLOW PAST THE ROOT SECTION OF A SWEPT WING [POSTROENIE EKVIVALENTNYKH PROFILEI I PRIBLIZHENNYI RASCHET OKOLOZVUKOVOGO OBTEKANIIA KORNEVOGO SECHENIIA STRELOVIDNOGO KRYLA]

G. A. PAVLOVETS and A. L. SHKADOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 7-14. In Russian. refs

A method is presented for calculating the contour of a profile whose pressrue diagram in plane-parallel flow is identical to that of the root section of a swept wing. These equivalent profiles are used for calculating stress distribution for the root profile of a swept wing for large subsonic flow velocities. The calculated results are compared with experimental data. V.L.

**A86-13397**

### DETERMINATION OF THE SHAPE OF A PROFILE FROM A SPECIFIED CHORD DIAGRAM OF MACH NUMBERS IN TRANSONIC FLOW [OPREDELENIE FORMY PROFILIA PO ZADANNOI KHORDOVOI DIAGRAMME CHISEL MAKHA V TRANSZVUKOVOM POTOKE]

A. A. SHAGAEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 15-23. In Russian. refs

The method of successive approximations is extended to the case of subsonic and transonic flows of an ideal gas. In particular, attention is given to the inverse problem in the profile theory, and an iteration procedure is presented for solving this problem on the basis of a specified chord diagram of Mach numbers for subsonic and transonic velocities. Results are presented in graphical form. V.L.

**A86-13398**

**USING THE SHOCK-EXPANSION METHOD FOR CALCULATING THE AERODYNAMIC CHARACTERISTICS OF FLIGHT VEHICLES [PRIMENENIE METODA 'SKACHKOV-RASSHIRENII' DLIA RASCHETA AERODINAMICHESKIKH KHARAKTERISTIK LETATEL'NYKH APPARATOV]**

V. F. SIAGAEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 24-28. In Russian. refs

The principal relationship of the second-order shock-expansion method is analyzed. A further simplification of this relationship is then proposed, which makes it possible to reduce the time required for the approximate calculation of the aerodynamic characteristics of bodies with nearly linear generatrices. Calculations are carried out for a cone-cylinder combination. V.L.

**A86-13399**

**A STUDY OF HEAT TRANSFER ON WEDGES WITH A SWEPT LEADING EDGE AND A SHARPLY BENT GENERATRIX [ISSLEDOVANIE TEPLOPEREDACHI NA KLIN'IAKH SO SKOSHENNOI PEREDNEI KROMKOI I IZLOMOM OBRAZUIUSHCHEI]**

V. N. BRAZHKO, A. P. KOSYKH, and N. N. SHKIRIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 29-37. In Russian. refs

The aerodynamic and heat transfer characteristics of wedges with various degrees of the leading edge sweep (0-75 deg) and with a sharply bent generatrix are investigated experimentally and analytically for free-stream Mach 4 and 5 and for Re = (7.1-20.7)x10 to the 6th. It is shown that an increase in the leading edge sweep and local roughness of the leading edge lead to a premature turbulent transition of the boundary layer, with the associated maxima of heat transfer coefficients on the wedge surface. The end of the transition region can be located very close to leading edge of the wedge. V.L.

**A86-13406**

**THE EFFECT OF A PERFORATED WALL ON INCOMPRESSIBLE FLOW PAST A U-SHAPED VORTEX [VLIIANIE PERFORIROVANNOI STENKI NA OBTEKANIEI U-OBRAZNOGO VIKHRIA NESZHIMAEMYM POTOKOM]**

A. V. SEMENOV and O. K. CHIKINA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 99-102. In Russian.

The perturbed velocity potential due to the interaction between a U-shaped vortex and a horizontal or vertical permeable wall in incompressible flow is determined. It is shown that the effect of a permeable wall can be simulated by a simple set of singularities. Corrections for the induction downwash over the span of a U-shaped vortex are calculated for various wall permeability coefficients. V.L.

**A86-13411**

**LINEAR THEORY OF AN EQUIVALENT PROFILE IN THE PROBLEM CONCERNING THE INFLUENCE OF POROUS FLOW BOUNDARIES [LINEINAIA TEORIIA EKVIVALENTNOGO PROFILIA V ZADACHE O VLIIANII PERFORIROVANNYKH GRANITS POTOKA]**

L. G. IVANTEEVA and G. A. PAVLOVETS TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 1-9. In Russian. refs

A solution is obtained for the flow problem for a profile situated in the middle of a channel with porous walls. The analysis is based on a numerical solution of a singular integral equation for the density of the vortex sheet distributed along the chord of the profile. Equivalent-profile theory is used to determine the pressure distribution on a given profile in a channel with porous walls for large subsonic and transonic speeds. B.J.

**A86-13412**

**THE USE OF REVERSE FLOW TO CALCULATE TRANSONIC FLOW PAST BODIES [ISPOL'ZOVANIE OBRASHCHENNOGO POTOKA DLIA RASCHETA OKOLOZVUKOVOGO OBTEKANIIA TEL]**

IU. A. ARUTIUNOV and V. V. VYSHINSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 10-18. In Russian. refs

The reversibility paradox, valid for subcritical transonic flows, is extended to the case of isentropic flow with compression shocks by introducing rarefaction shocks into the reverse flow. It is shown that the same solution can be obtained when calculating the flow in forward and reverse flows. The use of the reverse flow makes possible a two-fold reduction in computational time when implementing transonic-flow computation methods on multiprocessors. B.J.

**A86-13413**

**ASYMPTOTIC SOLUTION OF THE FLUID-FLOW PROBLEM IN THE CORE OF A VORTEX SHEET [ASIMPTOTICHESKOE RESHENIE ZADACHI O TECHENII ZHIDKOSTI V IADRE VIKHREVOI PELENY]**

A. M. GAIFULLIN and A. V. ZUBTSOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 19-29. In Russian. refs

An analysis is made of the flow arising in the core of a vortex sheet due to flow separation from a low-aspect-ratio delta wing at small angles of attack and large Reynolds numbers. An asymptotic solution is obtained on the basis of the complete equations of motion of a viscous incompressible fluid. The asymptotic dependence of flow characteristics in the core of the vortex sheet on alpha, Re, and mean alpha is obtained. B.J.

**A86-13422**

**EFFECT OF CANTILEVERS ON THE LIFT CHARACTERISTICS OF A THIN SWEPT WING AND VORTEX-WAKE STABILITY [VLIIANIE KONSOLEI NA NESUSHCHIE SVOISTVA TONKOGO STRELOVIDNOGO KRYLA I USTOICHIVOST' VIKHREVOGO SLEDA]**

E. P. VIZEL TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 113-118. In Russian. refs

Experimental results indicate that the placement of cantilevers on a delta wing leads to the interaction of vortex sheets separating from the leading edges and the cantilever, and having different degrees of stability. The presence of a leading-edge break point and a reduction in the cantilever sweep leads to an accelerated breakdown of the vortex and a reduction in c(ya)max. B.J.

**A86-13423**

**CALCULATION OF SUPERSONIC FLOW PAST A THREE-DIMENSIONAL CONFIGURATION USING INTEGRAL RELATIONSHIPS [RASCHET SVERKHZVUKOVOGO OBTEKANIIA PROSTRANSTVEN[illegible] KONFIGURATSII S ISPOL'ZOVANIEM INTEGRAL'NYKH SOOTNOSHENII]**

T. V. POGREBNAIA and V. V. SAMSONOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 119-124. In Russian. refs

A numerical method is proposed which can be used to determine the distributed and overall aerodynamic characteristics in supersonic flow past a system of arbitrary surfaces (wings, tail unit, air intake, and the vehicle as a whole) in the framework of the linear approximation. A uniform accuracy of aerodynamic-load determination is assured on all the surfaces. The boundary value problem concerning the determination of surface loads is reduced to a system of integral equations, which are solved by the method of successive approximations. B.J.

**A86-13426**

**CALCULATION OF FLOW AROUND ROTATING CIRCULAR CASCADES WITH ALLOWANCE FOR CIRCUMFERENTIAL FLOW NONUNIFORMITY INDUCED BY A PERTURBATION AT THE INLET [K RASCHETU OBTEKANIIA VRASHCHAIUSHCHIKHSIA KRUGOVYKH RESHETOK S UCHETOM OKRUZHNOI NERAVNOMERNOSTI POTOKA, VYZVANNOI VOZMUSHCHENIEM NA VKHODE]**

E. S. BELIANOVSKII, V. B. KURZIN, and T. S. SOLOMAKHOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 137-142. In Russian. refs

The method of solution and results are presented for the direct problem concerning the unsteady flow around a rotating circular cascade of thin curved profiles with allowance for circumferential flow nonuniformity induced by a perturbation at the inlet. The perturbation is modeled as a displacement of a vortex source from the center of the cascade. The solution of the integral equation for the circulation intensity on the profiles is obtained by the discrete-vortex method. The effect of cascade parameters and of the displacement magnitude of the vortex source on the circulation intensity on the profiles is analyzed. B.J.

**A86-13427**

**THEORY OF SELF-SIMILAR REGIMES OF SUPERSONIC FLOW IN AN AXISYMMETRIC CHANNEL WITH A SUDDEN EXPANSION [K TEORII AVTOMODEL'NYKH REZHIMOV SVERKHZVUKOVOGO TECHENIIA V OSESIMMETRICHNOM KANALE S VNEZAPNYM RASSHIRENIEM]**

A. I. OVCHINNIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 143-148. In Russian. refs

The paper develops a method for calculating base pressure at an annular projection in a system comprising a supersonic nozzle and a cylindrical channel for regimes where the relative base pressure is self-similar with respect to the gas-jet pressure. The method is based on an interpretation of available experimental data and does not contain any empirical coefficients. The calculation results are compared with the experimental results of previous studies. B.J.

**A86-13429**

**FORMATION OF ASYMMETRIC SEPARATED FLOW PAST SLENDER BODIES OF REVOLUTION AT LARGE ANGLES OF ATTACK [K VOZNIKNOVENIIU NESIMMETRICHNOGO OTRYVNOGO OBTEKANIIA TONKIKH TEL VRASHCHENIIA NA BOL'SHIKH UGLAKH ATAKI]**

M. G. GOMAN and A. N. KHRABROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 1-9. In Russian. refs

The paper examines the problem of determining stationary positions of pairs of vortices of unequal intensity in the flow behind a cylinder modeling the axisymmetric separated flow past a slender body at large angles of attack. The possible asymmetric stationary positions of two vortices are calculated, and their stability with respect to small perturbations is determined. Bifurcations of the flow field with changes in vortex intensity are analyzed. B.J.

**A86-13431**

**CERTAIN PROPERTIES OF TWO-DIMENSIONAL FLOWS IN THE CASE OF FLOW PAST BODIES WITH JETS [O NEKOTORYKH SVOISTVAKH PLOSKIKH TECHENII PRI OBTEKANII TEL SO STRUIAMI]**

V. M. SHURYGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 19-26. In Russian.

Shurygin's (1977) approach is used to study the nonseparated flow, an ideal incompressible fluid past bodies with jets as Be numbers not equal to zero. Representations of the Joukowski functions at an infinitely distant point are given, and formulas for the overall forces acting on the body are presented. A relationship is established between the behavior of the Joukowski functions, the total circulation, and the overall flowrate. B.J.

**A86-13433**

**COMPACT GAS EJECTOR OF A HIGH DEGREE OF COMPRESSION WITH SPIRAL ARRANGEMENT OF THE NOZZLES [KOMPAKTNYI GAZOVYI EZHEKTOR BOL'SHOI STEPENI SZHATIIA S RASPOLOZHENIEM SOPL PO SPIRALI]**

IU. K. ARKADOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 35-42. In Russian. refs

The design is described and experimental results are presented for a compact gas ejector which achieves a high degree of compression (up to 500). The ejector has a single forechamber, a single mixing chamber, and a single regulating element. High-pressure-head gas is fed into the ejector through 45 inclined supersonic nozzles spirally distributed around and along the mixing chamber. Besides exhibiting a high degree of compression, this ejector has 30 percent better cost efficiency than existing multistage ejectors. B.J.

**A86-13440**

**SUPERSONIC GAS FLOW PAST A V-SHAPED WING [OBTEKANIE V-OBRAZNOGO KRYLA SVERKHZVUKOVYM POTOKOM GAZA]**

T. M. PRITULO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 97-102. In Russian. refs

Pritulo's (1983) method is used to calculate pressure on the surface of a V-shaped wing with supersonic leading edges. On the lower surface of the wing, the flow is linearized with respect to a plane-parallel stream that has passed through a shock attached to the leading edge, the shock is calculated approximately as an isentropic compression. On the upper surface of the wing, the flow is linearized with respect to a plane-parallel stream that has passed through a rarefaction wave. B.J.

**A86-13456**

**AEROHYDROMECHANICS [AEROGIDROMEKHANIKA]**

A. M. MKHITARIAN, ED. Moscow, Izdatel'stvo Mashinostroenie, 1984, 352 p. In Russian. No individual items are abstracted in this volume.

The theoretical fundamentals of aerohydromechanics are examined, with attention given to hydroaerostatics, fluid and gas kinematics, ideal fluid dynamics, similarity and dimensionalities, isentropic flows, shock waves, hydraulic path drag, and boundary layer theory. Various problems in applied aerohydromechanics are then discussed, including wings and airfoils in subsonic, transonic, and supersonic flight, the aerodynamics of bodies of revolution and controls, and the aerodynamic characteristics of an aircraft as a whole. Finally, the discussion focuses on problems in hydraulics, such as calculation of local hydraulic resistance, hydraulic lines, and flows from holes and nozzles. V.L.

**A86-13532**

**BOUNDARY-LAYER DEVELOPMENT ON THE AFTERBODY OF AN ENGINE NACELLE**

E. LAI and L. C. SQUIRE (Cambridge University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 158, Sept. 1985, p. 23-46. Research supported by the Ministry of Defense (Procurement Executive) and Department of Trade and Industry. refs

In the context of the estimation of the drag of a complete aircraft, the calculation of the drag associated with the engine installation presents some particular difficulties. Thus, the nacelle afterbody drag represents a critical area which has been investigated for the past few years. The present paper provides the results of an experimental investigation of the boundary-layer development on a body of revolution with a jet issuing from the base. Detailed boundary-layer measurements were made with a jet velocity of 2.5 times the free-stream velocity. The main effects of replacing a jet by a solid cylindrical sting are discussed. G.R.

**A86-13546#**

**A SOLUTION OF INVERSE PROBLEM FOR MULTI-ELEMENT AEROFOILS THROUGH APPLICATION OF PANEL METHOD**

M. SHIGEMI (National Aerospace Laboratory, Tokyo, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 28, Aug. 1985, p. 97-107. refs

A solution to the inverse problem of a multielement airfoil is presented. This solution is based on the panel method, in which vortex is chosen as singularity to be distributed around the airfoil. Because of this choice, the solution becomes very simple in comparison with other types of panel methods. To meet the requirements for the solution of inverse problem as a tool to design airfoils, it is possible in this method to obtain an airfoil whose trailing edge is always closed, and the velocity distribution around which is as close to the prescribed one as possible. With a little modification, the present method can give a solution to a problem, which is direct for some elements of a multielement airfoil, but inverse for other elements. This solution is useful when some elements of a multielement airfoil are modified in shape to get a better performance. Author

**A86-13933**

**A METHOD FOR NUMERICAL ANALYSIS OF THE AERODYNAMIC CHARACTERISTICS OF AN AEROPLANE WING IN THE SUBCRITICAL RANGE OF THE FLYING VELOCITY**

Z. DZYGADLO and T. X. CHU Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 1, 1984, p. 127-141. refs

A method for determining the aerodynamic characteristics of an aircraft wing making use of a hydrodynamic model composed of discrete vortices is described. Using this method, the coefficients of lift, drag, and transverse force, as well as those of the rolling, pitching, and yawing moments, which act on a wing in incompressible or compressible flow, can be obtained. Here, the circulation flow with attached vortices and separated vortices flowing away from the edges of the wing are studied.Two models of flow are analyzed, with and without leading-edge separation. C.D.

**A86-14186**

**A STUDY OF THE FLOW AROUND A WING EQUIPPED WITH A SPOILER [CONTRIBUTION A L'ETUDE EXPERIMENTALE ET THEORIQUE DE L'ECOULEMENT AUTOUR D'UN PROFIL D'AILE MUNI D'UN SPOILER]**

B. C. JAEGGY, W. CZICHOWSKY, P. MEYER, G. KOERBER, and R. KAUFFMANN (Saint-Louis, Institut Franco-Allemand de Recherches, France) L'Aeronautique et L'Astronautique (ISSN 0001-9275), no. 112, 1985, p. 2-20. In French. refs
(Contract DRET-82-318; DRET-84-047)

Laser velocimetry and flow visualization data were analyzed for flow around a wing equipped with a spoiler. Two- and three-dimensional velocity data were collected and photographs were taken of the flow seeded with dense oil smoke and illumined by a laser beam and a stroboscope. Attention was focused on the unsteady wake characteristics, the turbulent structures and length scales, the velocity profiles, the Reynolds stress and the pressure distributions. The data were analyzed using the nonviscous model of Maskew and Dvorak (1979). The results demonstrate the feasibility of examining separated flows using laser velocimetry and minimal computing power. Studies of the flows past a spoiler will require further trials, however, particularly for the Re stress. M.S.K.

**A86-14359**

**UNSTEADY POTENTIAL FLOW FOR OSCILLATING AIRFOILS**

I. PARASCHIVOIU (Montreal, Universite, Montreal, Canada) and J.-M. PARROUFFE Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, June 1985, p. 142-158. refs

Attention is given to the development status of an aerodynamic model for the unsteady potential flow about a blade profile, which would be applicable in calculations of the forces acting on Darrieus wind turbine rotor blades. The technique applied to unsteady potential flow distributes elementary singularities uniformly over the profile surface, as well as local singularities in the wake. Such parameters as pressure distribution, lift coefficient, moment coefficient, and time-dependent variations of the wake, are thereby calculated for various profile motions. The model has been validated for symmetrical profiles (undergoing pitching) whose maximum incidence does not exceed the static stall angle. O.C.

**A86-14360#**

**A NEW FAST SOLVER PROCEDURE APPLIED TO THE BGK COMPUTER PROGRAM FOR TRANSONIC FLOW PAST AN AEROFOIL**

Y. S. WONG (Alberta, University, Edmonton, Canada) and D. J. JONES (National Aeronautical Establishment, Ottawa) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, June 1985, p. 159-169. refs
(Contract NSERC-U-0375)

A fast iterative procedure has been developed for calculating the nonconservative full potential transonic flow equation. The numerical method consists of two level iterations: the outer iterate is based on a Newton-like algorithm, and the inner iterate is based on a preconditioned minimal residual method. This method has been tested on the computer program for transonic flow past an aerofoil, originally developed by Bauer, Garabedian and Korn (1972) and often referred to as the 'BGK' code. Computational results from the present method are compared with results from a previous fast solver due to Jameson (1974). The comparison for different Mach numbers and angles of attack is very good in the inviscid case, and reasonably good in the viscous case in which Green's (1973) boundary layer method is used. The present method, howver, gives a reduction in computing time of 40 percent in inviscid calculations, while in the viscous case savings of about 25 percent can be achieved in computer time. Author

**A86-14432#**

**EVALUATION OF A METHOD FOR ANALYZING THE APERTURE REGION OF TWO-DIMENSIONAL EXTERNAL COMPRESSION INLETS**

A. F. CAMPBELL and C. K. FORESTER (Boeing Military Airplane Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(AIAA PAPER 85-3072)

A two-dimensional Navier-Stokes code is used to compute the flow field in the aperture region of a two-dimensional external compression inlet. The goals of the study are to first establish the ability of the code to correctly predict the relative performance characteristics of previously tested aperture region designs and then use the code as a tool to derive additional design information for optimizing external compression inlet performance. Progress on the validation of the two-dimensional Navier-Stokes procedure is reported. Analytical results are compared with experimental data for one aperture region geometry. The influence of numerical smoothing and cross stream grid resolution on solution accuracy is investigated. Author

**A86-14451#**

**VISCOUS FLOW RESULTS FOR THE VORTEX-AIRFOIL INTERACTION PROBLEM**

J. C. WU, T. M. HSU, W. TANG, and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. USAF-Army-supported research. refs
(AIAA PAPER 85-4053)

The unsteady airfoil-vortex interaction problem is analyzed using two solution procedures. In the first procedure, the unsteady, incompressible Navier-Stokes equations are solved in the vorticity-stream function form using an integro-differential formulation. In the second approach, the compressible Navier-Stokes equations are solved using an Alternating Direction Implicit (ADI) procedure. Both the approaches use a body-fitted coordinate system. The effects of turbulence are modeled using a two-layer eddy viscosity model. Numerical results are presented for the interaction of a passing vortex with a NACA 0012 airfoil and a NACA 64A006 airfoil for a wide range of flow parameters and compared with available numerical data. Author

**A86-14452*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### THE EFFICIENT SIMULATION OF SEPARATED THREE-DIMENSIONAL VISCOUS FLOWS USING THE BOUNDARY-LAYER EQUATIONS

W. R. VAN DALSEM and J. L. STEGER (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(AIAA PAPER 85-4064)

A simple and computationally efficient algorithm for solving the unsteady three-dimensional boundary-layer equations in the time-accurate or relaxation mode is presented. Results of the new algorithm are shown to be in quantitative agreement with detailed experimental data for flow over a swept infinite wing. The separated flow over a 6:1 ellipsoid at angle of attack, and the transonic flow over a finite-wing with shock-induced 'mushroom' separation are also computed and compared with available experimental data. It is concluded that complex, separated, three-dimensional viscous layers can be economically and routinely computed using a time-relaxation boundary-layer algorithm. Author

**A86-14453#**

### UNSTEADY AERODYNAMICS OF AIRFOILS OSCILLATING IN AND OUT OF DYNAMIC STALL

C. M. WANG, J. C. WU, and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. Army-supported research. refs
(AIAA PAPER 85-4078)

A solution procedure is presented for the computation of dynamic stall phenomena encountered by arbitrary shaped airfoils under arbitrary flow conditions. This procedure solves the unsteady, incompressible Navier-Stokes and the unsteady boundary layer equations using an efficient, zonal approach. A number of results for a modified NACA 0012 airfoil experiencing dynamic stall are presented and compared with available numerical data. Qualitative comparisons with flow visualization experiments are also presented. The present study also illustrates the effect of numerical viscosity on the accuracy and robustness of the solution procedure. Author

**A86-14454*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### JUNCTURE FLOW CONTROL USING LEADING-EDGE FILLETS

L. R. KUBENDRAN and W. D. HARVEY (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 6 p. Research supported by the National Research Council and NASA. refs
(AIAA PAPER 85-4097)

Flow measurements have been made in the wake region of a simulated wing-fuselage juncture, with and without leading-edge fillets, in order to assess the effect of leading-edge modifications on the flow field around the juncture. Preliminary results indicate that there is some reduction in juncture drag at moderate angles of attack with the use of leading-edge fillets. There is also evidence of improvement in the flow characteristics on the surface downstream of the juncture when fillets are used. As the fillet size is increased, flow characteristics start deteriorating at some point, and an optimum fillet size may be required to achieve an overall improvement in the flow field. Author

**A86-14455#**

### COMPUTATION OF ROTOR BLADE FLOWS USING THE EULER EQUATIONS

B. E. WAKE, N. L. SANKAR, and S. G. LEKOUDIS (Georgia Institute of Technology, Atlanta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. Army-supported research. refs
(AIAA PAPER 85-5010)

The Euler equations are used to compute steady and unsteady three-dimensional transonic flows around nonlifting rotor blades. A hybrid numerical procedure is used that treats the spanwise derivatives explicitly and the other spatial derivatives implicitly. The steady state results are in excellent agreement with results obtained from the full potential equation. The results for unsteady flow compare well with measurements. These results demonstrate the ability of the Euler solver to compute transonic flow around helicopter blades. Author

**A86-14456#**

### SOLUTION OF TRANSONIC FLOW PAST ROTOR BLADES USING THE CONSERVATIVE FULL POTENTIAL EQUATION

L. N. SANKAR (Georgia Institute of Technology, Atlanta) and D. PRICHARD (McDonnell Douglas Helicopter Co., Culver City, CA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 11 p. Research supported by the McDonnell Douglas Helicopter Co. refs
(AIAA PAPER 85-5012)

A solution procedure is presented for the prediction of unsteady, transonic flow past helicopter rotor blades in forward flight. This procedure solves the three-dimensional, unsteady, compressible full potential equation in conservation form in a body-fitted coordinate system using a Strongly Implicit Procedure (SIP). It is assumed that the structure of the unsteady wake, as well as the structural deformation of the rotor blade due to the aerodynamic loads are known independently from a free wake-aeroelastic analysis. These effects are accounted for as corrections to the section angle of attack at several radial stations. Numerical results are presented for a number of rotor configurations in forward flight, and compared with available experimental data. Author

**A86-14457#**

### VELOCITY MEASUREMENTS IN THE NEAR FIELD OF A ROTOR BLADE IN HOVER

N. M. KOMERATH, T. L. THOMPSON, and R. B. GRAY (Georgia Institute of Technology, Atlanta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 13 p. refs
(Contract DAAG29-82-K-0094)
(AIAA PAPER 85-5013)

Measurements of the velocity field close to a model rotor blade in hover are described. The flow around the tip of the blade has been emphasized in determining the measurement grid. A large data base has been constructed for quantitative comparison with predictions. The data has been used to construct qualitative pictures of the instantaneous flow field in several planes parallel and normal to the blade planform. Selected plots of velocity components measured during the passage of the blade have also been presented for quantitative comparison with prediction techniques. Preliminary comparison of the spanwise distribution of circulation with computed values is shown. The data shows the roll-up of the velocity field around the tip into a tip vortex and the flow patterns on planes above and below the blade. Predicted results are seen to be in good agreement with the measured values at inboard stations, but more work is seen to be necessary for better prediction of the flow around the tip. Sources of possible error in the measurement are discussed. Author

**A86-14529#**
**SEPARATED FLOW UNSTEADY AERODYNAMIC THEORY**
R. M. CHI (United Technologies Research Center, East Hartford, CT) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 27-37) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 956-964. Research sponsored by the United Technologies Corp. Previously cited in issue 13, p. 1832, Accession no. A84-31687. refs

**A86-14537#**
**DOUBLET STRIP METHOD FOR OSCILLATING SWEPT TAPERED WINGS IN INCOMPRESSIBLE FLOW**
A. ICHIKAWA (Civil Aviation College, Miyazaki, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 1008-1012. refs

An improved numerical method is developed for calculating the load distributions on oscillating swept tapered wings in incompressible flow. The integration domains is transformed into a rectangular domain, and the domain is divided into many chordwise strips. In the strip containing the control point, the proposed method properly accounts for Cauchy and logarithmic singularities. The solutions generally compared well with other lifting-surface theories, but with much smaller computational times. Author

**A86-14541#**
**COMMENT ON 'AERODYNAMIC ESTIMATION TECHNIQUES FOR AEROSTATS AND AIRSHIPS'**
G. DELEUTERIO (Toronto, University, Canada) and B. ETKIN Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 1023; Authors' reply, p. 1023, 1024. refs

**A86-14556#**
**MULTISTAGE COMPRESSOR STATOR/ROTOR INTERACTION**
D. L. TWEEDT, T. H. OKIISHI (Iowa State University of Science and Technology, Ames), and M. D. HATHAWAY (U.S. Army, Research and Technology Laboratories, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 449-455. Previously cited in issue 07, p. 835, Accession no. A85-19455. refs
(Contract F49620-83-K-0023)

**A86-14558*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.
**CALCULATION OF UNSTEADY FAN ROTOR RESPONSE CAUSED BY DOWNSTREAM FLOW DISTORTIONS**
W. F. OBRIEN, W.-F. NG, and S. M. RICHARDSON (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 464-469. Previously cited in issue 03, p. 254, Accession no. A85-13960. refs
(Contract NAG1-156)

**A86-14559#**
**CALCULATION OF STEADY FLOW ABOUT PROPELLERS USING A SURFACE PANEL METHOD**
J. L. HESS and W. O. VALAREZO (Douglas Aircraft Co., Long Beach, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 470-476. Navy-sponsored research. Previously cited in issue 07, p. 842, Accession no. A85-19634. refs

**A86-14560#**
**A LINEAR MULTIVARIABLE DYNAMICAL MODEL OF A SUPERSONIC INLET-ENGINE COMBINATION**
Y. GUAN, S. YARNG (Northwestern Polytechnical University, Xian, People's Republic of China), and J. YARNG Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 477-484. Previously cited in issue 16, p. 2278, Accession no. A84-35239. refs

**A86-14561*#** Texas Technological Univ., Lubbock.
**MULTISPARK FLOW VISUALIZATION OF LATERAL JET INJECTION INTO A SWIRLING CROSS FLOW**
G. B. FERRELL (Texas Tech University, Lubbock), K. AOKI, and D. G. LILLEY (Oklahoma State University, Stillwater) Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 485-487. Previously cited in issue 07, p. 836, Accession no. A85-19490. refs
(Contract NAG3-549)

**A86-14679**
**A NUMERICAL METHOD FOR CALCULATING INTERNAL SUBSONIC SWIRLING FLOWS OF AN IDEAL GAS [CHISLENNYI METOD RASCHETA VNUTRENNIKH DOZVUKOVYKH TECHENII IDEAL'NOGO GAZA S ZAKRUTKOI]**
V. P. PASHCHENKO Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 25, Oct. 1985, p. 1573-1577. In Russian. refs

An analysis is made of internal subsonic swirling flows of an ideal gas in axisymmetric ducts with a sharp bend. Calculations are carried out in orthogonal coordinates using an iteration procedure; examples of calculations are presented. V.L.

**A86-14743**
**MEASUREMENT OF THE HETEROGENEOUS RECOMBINATION PROBABILITY OF OXYGEN ATOMS IN THE COURSE OF SUPERSONIC DISSOCIATED GAS FLOW INTERACTION WITH SOLID BODY SURFACES**
V. D. BERKUT, V. V. KOVTUN, N. N. KUDRIAVTSEV, S. S. NOVIKOV, and A. I. SHAROVATOV (AN SSSR, Institut Khimicheskoi Fiziki, Moscow, USSR) International Communications in Heat and Mass Transfer (ISSN 0735-1933), vol. 12, Sept.-Oct. 1985, p. 567-575. refs

A method for determining time-resolved heterogeneous recombination probabilities of oxygen atoms is described. This technique is based on the comparison of the measured and calculated heat fluxes to a flat wedge-like plate set at a small expansion angle to a supersonic dissociated gas flow with pressure of 100 mm Hg, temperature 3000-4000 K, and velocity of 2.5-3.0 km/sec. The relationship between incident shock wave Mach numbers and full dissociation of oxygen and the absence of gas recombination in the boundary layer is analyzed. The calculation of the relative fraction of the recombination of heat flux using a new heat transfer gauge technique is examined. This gauge technique, which is dependent on the surface reaction Damkohler number produces higher fractions of the recombination of heat fluxes than the previous gauge method. Experimental procedures and results revealing the applicability of this method for calculating recombination probabilities are provided. I.F.

**A86-15980**
**EXPERIMENTAL STUDY OF GAS FLOW AROUND BLUNT OBJECTS**
A. P. BEDIN, G. I. MISHIN, and M. V. CHISTIAKOVA (AN SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR) (Zhurnal Tekhnicheskoi Fiziki, vol. 55, Apr. 1985, p. 719-722) Soviet Physics - Technical Physics (ISSN 0038-5662), vol. 30, April 1985, p. 423-425. Translation. refs

The effects the physical properties of a gas have on the flow around segmented and conical objects were studied experimentally using ballistic models in air, argon and Freon-12. Air trials were carried out at ambient pressure while the pressures of the other gases were altered to maintain an Re of 650,000 at Mach numbers from 0.5-4 in Ar (and air) and from 1-9 in Freon-12. The flows were monitored in separated and attached regions and in the near wake. The rotation angle of the flow about the apex increased with decreases in the specific heat ratio (SHR), and was associated with expansion of the area of attached flow on the lateral surface. A relationship was observed between critical angle for separation and the Mach number in all gases. Any decrease in the SHR was accompanied by a decrease in the size of the detached flow region. M.S.K.

**A86-16102**
**MEASUREMENTS IN THE TURBULENT BOUNDARY LAYER ON AN 'INFINITE' SWEPT WING**
P. BRADSHAW and N. S. PONTIKOS (Imperial College of Science and Technology, London, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 159, Oct. 1985, p. 105-130. refs

The present paper is concerned with turbulence measurements on an 'infinite' swept wing, simulated by a duct attached to a blower tunnel. The work considered represents an extension of studies reported by van den Berg et al. (1975) and Elsenaar and Boelsma (1974). The current work shows in greater detail that the influence of mean-flow three-dimensionality on the dimensionless structure parameters of the turbulence is more extensive and more subtle than assumed in present calculation methods, which concentrate on the lag in direction of the shear-stress vector while not fully accounting for the decrease in magnitude implied by the experimental results. A few sample results for Reynolds-stress transport normal to the surface are presented. The paper is mainly concerned with the outer layer of the boundary layer. G.R.

**A86-16122**
**PRESSURE FLUCTUATIONS ON ROTOR BLADES GENERATED BY BLADE-VORTEX INTERACTION**
G. NEUWERTH and R. MUELLER (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) (European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 3, 1985, p. 227-239. refs

During some flight operations of helicopters the main rotor blades pass close to or intersect the trailing tip vortices of the main rotor. These blade-vortex interactions (BVI) generate strong fluctuating blade pressures leading to dynamic structural loads and impulsive noise radiation. Currently, accurate load predictions are limited by the lack of knowledge of the tip vortex structure. Therefore, a special test facility was built to investigate the basic mechanism of BVI: a special delta wing generates two leading edge vortices with a structure measured by a five-hole probe. One of these vortices interacts with a rotor which represents the main rotor. The forward flight of the helicopter is simulated by a wind tunnel. By this arrangement a better physical understanding of the BVI can be obtained. Additionally, theoretical methods for computing the local unsteady blade pressures can be checked more reliably. The pressure fluctuations are computed by means of a theory which was derived from the unsteady airfoil theory of Naumann and Yeh. Measured and computed pressure fluctuations are in good agreement. Author

**N86-12202*#** Grumman Aerospace Corp., Bethpage, N.Y.
**GRUMFOIL: A COMPUTER CODE FOR THE VISCOUS TRANSONIC FLOW OVER AIRFOILS Final Report**
H. R. MEAD and R. E. MELNIK Washington NASA Oct. 1985 76 p refs
(Contract NAS1-12426)
(NASA-CR-3806; NAS 1.26:3806; RE-681) Avail: NTIS HC A05/MF A01 CSCL 01A

A user's manual which describes the operation of the computer program, GRUMFOIL is presented. The program computes the viscous transonic flow over two dimensional airfoils using a boundary layer type viscid-inviscid interaction approach. The inviscid solution is obtained by a multigrid method for the full potential equation. The boundary layer solution is based on integral entrainment methods. E.A.K.

**N86-12203*#** Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
**THE STATUS OF TWO-DIMENSIONAL TESTING AT HIGH TRANSONIC SPEEDS IN THE UNIVERSITY OF SOUTHAMPTON TRANSONIC SELF-STREAMLINING WIND TUNNEL Progress Report**
M. C. LEWIS Washington NASA Oct. 1985 57 p refs
(Contract NSG-7172)
(NASA-CR-3919; NAS 1.26:3919) Avail: NTIS HC A04/MF A01 CSCL 01A

This report briefly outlines the progress made during the last 2 years in extending the operational range of the Transonic Self-Streamlining Wind Tunnel (at the University of Southampton) into high subsonic speeds. Analytical preparation completed in order to achieve such an extension is outlined and a summary of the preliminary model validation tests is presented. Future work necessary to allow further validation and development is discussed. Author

**N86-12204*#** Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
**DERIVATION OF JACK MOVEMENT INFLUENCE COEFFICIENTS AS A BASIS FOR SELECTING WALL CONTOURS GIVING REDUCED LEVELS OF INTERFERENCE IN FLEXIBLE WALLED TEST SECTIONS**
M. J. GOODYER Oct. 1985 14 p refs Prepared for Kentron International, Inc., Hampton, Va.
(Contract NAS1-16000)
(NASA-CR-177992; NAS 1.26:177992) Avail: NTIS HC A02/MF A01 CSCL 01A

This report covers work done in a transonic wind tunnel towards providing data on the influence of the movement of wall-control jacks on the Mach number perturbations along the test section. The data is derived using an existing streamline-curvature program, and in application is reduced to matrices of influence coefficients. Author

**N86-12205*#** Rockwell International Corp., Columbus, Ohio. Aircraft Operations.
**AERODYNAMIC CHARACTERISTICS OF A PROPULSIVE WING-CANARD CONCEPT AT STOL SPEEDS Interim Report**
V. R. STEWART Nov. 1985 423 p refs
(Contract NAS1-17171)
(NASA-CR-177982; NAS 1.26:177982; NA84-0148) Avail: NTIS HC A18/MF A01 CSCL 01A

A full span model of a wing/canard concept representing a fighter configuration has been tested at STOL conditions in the NASA Langley 4 x 7 meter tunnel. The results of this test are presented, and comparisons are made to previous data of the same configuration tested as a semispan model. The potential of the propulsive wing/canard to develop very high lift coefficients was investigated with several nozzle spans (nozzle aspect ratios). Although longitudinal trim was not accomplished with the blowing distributions and configurations tested, the propulsive wing/canard appears to offer an approach to managing the large negative pitching moments associated with trailing edge flap blowing. Also presented are data showing the effects of large flap deflections and relative wing/canard positions. Presented in the appendix to the report are limited lateral-directional and ground effects data, as well as wing downwash measurements. Author

**N86-12206*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**EFFECT OF SURFACE WAVINESS ON A SUPERCRITICAL LAMINAR-FLOW-CONTROL AIRFOIL**
D. V. MADDALON and M. L. MCMILLIN Oct. 1983 25 p refs
(NASA-TM-85705; NAS 1.15:85705) Avail: NTIS HC A02/MF A01 CSCL 01A

Calculations were made of the effects of surface waviness on the external pressure of a supercritical airfoil at design conditions. Wave parameters varied include amplitude, wavelength, phase, and number of cycles. Effects of single and multiple waves are calculated at various chordwise locations. General trends of surface waviness effects on pressure distribution are determined and these solutions are reported. Contour deviations are imposed on the upper surface of the airfoil. Results are presented in a manner designed to facilitate ready comparison with the ideal contour static pressure distribution. Author

**N86-12207*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SOME RECENT ADVANCES IN COMPUTATIONAL AERODYNAMICS FOR HELICOPTER APPLICATIONS**
W. J. MCCROSKEY and J. D. BAEDER (Army Aviation and Technology Activity-AVSCOM, Moffett Field, Calif.) Oct. 1985 20 p refs
(NASA-TM-86777; REPT-85345; NAS 1.15:86777; USAVSCOM-TR-85-A-06) Avail: NTIS HC A02/MF A01 CSCL 01A

The growing application of computational aerodynamics to nonlinear helicopter problems is outlined, with particular emphasis on several recent quasi-two-dimensional examples that used the thin-layer Navier-Stokes equations and an eddy-viscosity model to approximate turbulence. Rotor blade section characteristics can now be calculated accurately over a wide range of transonic flow conditions. However, a finite-difference simulation of the complete flow field about a helicopter in forward flight is not currently feasible, despite the impressive progress that is being made in both two and three dimensions. The principal limitations are today's computer speeds and memories, algorithm and solution methods, grid generation, vortex modeling, structural and aerodynamic coupling, and a shortage of engineers who are skilled in both computational fluid dynamics and helicopter aerodynamics and dynamics. Author

**N86-12208*#** Grumman Aerospace Corp., Bethpage, N.Y.
**AN IMPROVED VISCID/INVISCID INTERACTION PROCEDURE FOR TRANSONIC FLOW OVER AIRFOILS Final Report**
R. E. MELNIK, R. R. CHOW, H. R. MEAD, and A. JAMESON Washington NASA Oct. 1985 132 p refs
(Contract NAS1-12426)
(NASA-CR-3805; NAS 1.26:3805; RE-682) Avail: NTIS HC A07/MF A01 CSCL 01A

A new interacting boundary layer approach for computing the viscous transonic flow over airfoils is described. The theory includes a complete treatment of viscous interaction effects induced by the wake and accounts for normal pressure gradient effects across the boundary layer near trailing edges. The method is based on systematic expansions of the full Reynolds equation of turbulent flow in the limit of Reynolds numbers, Reynolds infinity. Procedures are developed for incorporating the local trailing edge solution into the numerical solution of the coupled full potential and integral boundary layer equations. Although the theory is strictly applicable to airfoils with cusped or nearly cusped trailing edges and to turbulent boundary layers that remain fully attached to the airfoil surface, the method was successfully applied to more general airfoils and to flows with small separation zones. Comparisons of theoretical solutions with wind tunnel data indicate the present method can accurately predict the section characteristics of airfoils including the absolute levels of drag. E.A.K.

**N86-12209#** Naval Ship Research and Development Center, Bethesda, Md. Ship Performance Dept.
**AN EVALUATION OF FOUR METHODS OF NUMERICAL ANALYSIS FOR TWO-DIMENSIONAL AIRFOIL FLOWS. REVISION Departmental Report**
R. BURKE 6 Jul. 1985 29 p
(Contract S12-66)
(AD-A157248; DTNSRDC/SPD-1139-01-REV) Avail: NTIS HC A03/MF A01 CSCL 09B

Four computer programs for analyzing the inviscid and boundary layer flow over two dimensional airfoils are exercised in comparisons against experimental data from two wind tunnel studies. The solution method of each computer program is discussed, followed by a description of the airfoil geometries used in the model comparisons. Measured values of pressure distribution, turbulent separation point, and boundary layer properties are compared against predicted values. GRA

**N86-12210#** Naval Weapons Center, China Lake, Calif.
**PARACHUTE RECOVERY SYSTEMS DESIGN MANUAL, CHAPTERS 1 THROUGH 4 OFFPRINT Partial Report, Jan. 1984 - Jul. 1985**
T. W. KNACKE Jul. 1985 56 p
(AD-A157839; AD-E900488; NWC-TP-6575-CH-1/4) Avail: NTIS HC A04/MF A01 CSCL 01C

This manual provides the recovery system engineer in Government and industry with tools to evaluate, select, design, test, manufacture, and operate parachute recovery systems. These systems range from simple, one-parachute assemblies to multiple-parachute systems, and may include equipment for impact attenuation, flotation, location, retrieval, and disposition. All system aspects are discussed, including the need for parachute recovery, the selection of the most suitable recovery system concept, a computerized approach to parachute performance, force and stress analysis, geometric gore design, component layout, material selection, system design, manufacturing, and in-service maintenance. GRA

**N86-12434#** Joint Publications Research Service, Arlington, Va.
**BLR STUDIES ON CONIC MODEL WITH LDA IN FL-1 WIND TUNNEL**
Z. ZHAN and Y. YONG *In its* China Rept.: Sci. and Technol. (JPRS-CST-85-034) p 67-70 1 Oct. 1985 Transl. into ENGLISH from Guoji Hangkong (Beijing), no. 6, Jun. 1985 p 9-10
Avail: NTIS HC A08/MF A01

Boundary layer velocity measurement over a cone using laser (LDA) was studied in the FL-1 wind tunnel of the Shengyang Aerodnamics Research Institute. Velocity distributions at two cross-sections of the boundary layer of a 20 deg conic model under different Mach numbers are measured. The measured results are in agreement with theoretical calculations. E.A.K.

**N86-13287*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
**EFFECTS OF VELOCITY PROFILE AND INCLINATION ON DUAL-JET-INDUCED PRESSURES ON A FLAT PLATE IN A CROSSWIND**
A. L. JAKUBOWSKI, J. A. SCHETZ, C. L. MOORE, and R. JOAG Oct. 1985 52 p refs
(Contract NAG2-256)
(NASA-CR-177361; NAS 1.26:177361) Avail: NTIS HC A04/MF A01 CSCL 01A

An experimental study was conducted to determine surface pressure distributions on a flat plate with dual subsonic, circular jets exhausting from the surface into a crossflow. The jets were arranged in both side-by-side and tandem configurations and were injected at 90 deg and 60 deg angles to the plate, with jet-to-crossflow velocity ratio of 2.2 and 4. The major objective of the study was to determine the effect of a nonuniform (vs uniform) jet velocity profile, simulating the exhaust of a turbo-fan engine. Nonuniform jets with a high-velocity outer annulus and a low-velocity core induced stronger negative pressure fields than uniform jets with the same mass flow rate. However, nondimensional lift losses (lift loss/jet thrust lift) due to such nonuniform jets were lower than lift losses due to uniform jets. Changing the injection angle from 90 deg to 60 deg resulted in moderate (for tandem jets) to significant (for side-by-side jets) increases in the induced negative pressures, even though the surface area influenced by the jets tended to reduce as the angle decreased. Jets arranged in the side-by-side configuration led to significant jet-induced lift losses exceeding, in some cases, lift losses reported for single jets. B.W.

**N86-13288#** National Aerospace Lab., Tokyo (Japan).
**A METHOD FOR CALCULATING FLOW FIELDS AROUND MOVING BODIES**
S. OGAWA and T. ISHIGURO May 1985 23 p refs
(NAL-TR-859T; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

A new method for calculating flow fields with arbitrarily moving boundaries is proposed. Under the concept of Lie derivative, field equation moving coordinates are derived. There are several kinds of such equations; an exmaple is one written in Viviand's conservative form. According to the formulation presented, it is natural and reasonable to consider that the computation coordinates fitted to the body move in space. This is the reverse of the usual computational procedures. The two dimensional incompressible Navier-Stokes equations in general moving coordinates are solved by a finite difference method. Using the third-order upwind scheme (Kawamura scheme), the present calculations are made for the dynamic stall process on an oscillating airfoil, and the flow generated by a moving cylinder. Consequently it is shown that the flow generated by a moving body can easily be analyzed by the present method. Author

**N86-13291*#** Informatics General Corp., Palo Alto, Calif.
**PLTTER USER'S GUIDE**
A. BARLOW, D. HERMSTAD, and J. TROSIN Nov. 1985 64 p
(Contract NAS2-11555)
(NASA-CR-177385; NAS 1.26:177385; TN-85-7104-306-23)
Avail: NTIS HC A04/MF A01 CSCL 01A

The PLTTER graphics system, which is part of CDDMS is discussed. CDDMS is a comprehensive system for data basing and subsequent plotting of data acquired during wind tunnel tests or from computational flow analyses. The PLTTER is a system which creates report-quality plots of data which is stored on a CDDMS data base. The Requests file system allows plot-controlling information to be arranged in the way which is most appropriate for any application. The PLTTER system features many capabilities which are especially useful when plotting wind tunnel data. The PLTTER offers a variety of page formats, different grid options and parametric curve fitting algorithms, and a powerful legend capability to identify relavant information about individual curves. One or more plots on a page can be suppressed if desired so that an established page format can be maintained. Final plot output may be standard Versatec plots, QMS Laser printer plots, or microfiche. E.A.K.

**N86-13292*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**ON APPLICATIONS OF CHIMERA GRID SCHEMES TO STORE SEPARATION**
F. C. COUGHERTY, J. A. BENEK (Calspan Field Services, Arnold Air Force Station, Tenn.), and J. L. STEGER Oct. 1985 14 p refs
(NASA-TM-88193; REPT-86045; NAS 1.15:88193) Avail: NTIS HC A02/MF A01 CSCL 01A

A finite difference scheme which uses multiple overset meshes to simulate the aerodynamics of aircraft/store interaction and store separation is described. In this chimera, or multiple mesh, scheme, a complex configuration is mapped using a major grid about the main component of the configuration, and minor overset meshes are used to map each additional component such as a store. As a first step in modeling the aerodynamics of store separation, two dimensional inviscid flow calculations were carried out in which one of the minor meshes is allowed to move with respect to the major grid. Solutions of calibrated two dimensional problems indicate that allowing one mesh to move with respect to another does not adversely affect the time accuracy of an unsteady solution. Steady, inviscid three dimensional computations demonstrate the capability to simulate complex configurations, including closely packed multiple bodies. Author

**N86-13293*#** Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
**NUMERICAL SOLUTIONS OF NAVIER-STOKES EQUATIONS FOR A BUTLER WING Progress Report, 1 Jan. - 31 Aug. 1985**
J. S. ABOLHASSANI and S. N. TIWARI Oct. 1985 50 p refs
(Contract NCC1-68)
(NASA-CR-174202; NAS 1.26:174202) Avail: NTIS HC A03/MF A01 CSCL 01A

The flow field is simulated on the surface of a given delta wing (Butler wing) at zero incident in a uniform stream. The simulation is done by integrating a set of flow field equations. This set of equations governs the unsteady, viscous, compressible, heat conducting flow of an ideal gas. The equations are written in curvilinear coordinates so that the wing surface is represented accurately. These equations are solved by the finite difference method, and results obtained for high-speed freestream conditions are compared with theoretical and experimental results. In this study, the Navier-Stokes equations are solved numerically. These equations are unsteady, compressible, viscous, and three-dimensional without neglecting any terms. The time dependency of the governing equations allows the solution to progress naturally for an arbitrary initial initial guess to an asymptotic steady state, if one exists. The equations are transformed from physical coordinates to the computational coordinates, allowing the solution of the governing equations in a rectangular parallel-piped domain. The equations are solved by the MacCormack time-split technique which is vectorized and programmed to run on the CDC VPS 32 computer. Author

**N86-13294*#** Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
**AN INVESTIGATION INTO THE VERTICAL AXIS CONTROL POWER REQUIREMENTS FOR LANDING VTOL TYPE AIRCRAFT ONBOARD NONAVIATION SHIPS IN VARIOUS SEA STATES**
M. E. STEVENS and J. ROSKAM Jul. 1985 216 p
(Contract NCC2-242)
(NASA-CR-176355; NAS 1.26:176355; KU-FRL-623-1) Avail: NTIS HC A10/MF A01 CSCL 01A

The problem of determining the vertical axis control requirements for landing a VTOL aircraft on a moving ship deck in various sea states is examined. Both a fixed-base piloted simulation and a nonpiloted simulation were used to determine the landing performance as influenced by thrust-to-weight ratio, vertical damping, and engine lags. The piloted simulation was run using a fixed-based simulator at Ames Research center. Simplified versions of an existing AV-8A Harrier model and an existing head-up display format were used. The ship model used was that of a DD963 class destroyer. Simplified linear models of the pilot, aircraft, ship motion, and ship air-wake turbulence were developed for the nonpiloted simulation. A unique aspect of the nonpiloted simulation was the development of a model of the piloting strategy used for shipboard landing. This model was refined during the piloted simulation until it provided a reasonably good representation of observed pilot behavior. B.W.

**N86-13296*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**COMPUTATIONAL ASPECTS OF ZONAL ALGORITHMS FOR SOLVING THE COMPRESSIBLE NAVIER-STOKES EQUATIONS IN THREE DIMENSIONS**
T. L. HOLST, S. D. THOMAS (Informatics General Corp., Palo Alto, Calif.), U. KAYNAK, K. L. GUNDY, J. FLORES, and N. M. CHADERJIAN Oct. 1985 15 p refs
(NASA-TM-86774; REPT-85340; NAS 1.15:86774) Avail: NTIS HC A02/MF A01 CSCL 01A

Transonic flow fields about wing geometries are computed using an Euler/Navier-Stokes approach in which the flow field is divided into several zones. The flow field immediately adjacent to the wing surface is resolved with fine grid zones and solved using a Navier-Stokes algorithm. Flow field regions removed from the wing are resolved with less finely clustered grid zones and are solved with an Euler algorithm. Computational issues associated with this zonal approach, including data base management aspects, are discussed. Solutions are obtained that are in good agreement with experiment, including cases with significant wind tunnel wall effects. Additional cases with significant shock induced separation on the upper wing surface are also presented. Author

**N86-13297*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A TOMOGRAPHIC TECHNIQUE FOR AERODYNAMICS AT TRANSONIC SPEEDS**

G. LEE Oct. 1985 11 p refs
(NASA-TM-86766; REPT-85318; NAS 1.15:86766) Avail: NTIS HC A02/MF A01 CSCL 01A

Computer aided tomography (CAT) provides a means of noninvasively measuring the air density distribution around an aerodynamic model. This technique is global in that a large portion of the flow field can be measured. A test of the applicability of CAT to transonic velocities was studied. A hemispherical-nose cylinder afterbody model was tested at a Mach number of 0.8 with a new laser holographic interferometer at the 2- by 2-Foot Transonic Wind Tunnel. Holograms of the flow field were taken and were reconstructed into interferograms. The fringe distribution (a measure of the local densities) was digitized for subsequent data reduction. A computer program based on the Fourier-transform technique was developed to convert the fringe distribution into three-dimensional densities around the model. Theoretical aerodynamic densities were calculated for evaluating and assessing the accuracy of the data obtained from the tomographic method. Author

**N86-13298*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DOUBLE-BRANCHED VORTEX GENERATOR**

E. R. CANTWELL, R. V. WESTPHAL, and R. D. MEHTA (Stanford Univ., Calif.) Nov. 1985 25 p refs
(NASA-TM-88201; REPT-86064; NAS 1.15:88201) Avail: NTIS HC A02/MF A01 CSCL 01A

In order to assess the suitability of using a double branched vortex generator in parametric studies involving vortex interactions, an experimental study of the main vortex and secondary flows produced by a double branched vortex generator was conducted in a 20-by-40 cm indraft wind tunnel. Measurements of the cross flow velocities were made with a five hole pressure probe from which vorticity contours and vortex parameters were derived. The results showed that the optimum configuration consisted of chord extensions with the absence of a centerbody. Author

**N86-13299*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**GROUND EFFECTS ON V/STOL AND STOL AIRCRAFT: A SURVEY**

R. E. KUHN and J. ESHLEMAN Nov. 1985 27 p refs
(NASA-TM-86825; A-85356; NAS 1.15:86825) Avail: NTIS HC A03/MF A01 CSCL 01A

The flow fields encountered by jet- and fan-powered Vertical/Short Takeoff and Landing (V/STOL) aircraft operating in ground effect are reviewed and their general effects on the aerodynamic characteristics are discussed. The ground effects considered include: (1) the suckdown experienced by a single jet configuration in hover; (2) the fountain flow and additional suckdown experienced by multiple jet configurations in hover; (3) the ground vortex generated by jet and jet flap configurations in short takeoff and landing (STOL) operation and the associated aerodynamic and hot-gas-ingestion effects; and (4) the change in the downwash at the tail due to ground proximity. After over 30 years of research on V/STOL aircraft, the general flow phenomena are well known and, in most areas, the effects of ground proximity can be established or can be determined experimentally. However, there are some anomalies in the current data base which are discussed. Author

**N86-13300*#** Texas A&M Univ., College Station. Dept. of Aerospace Engineering.

**A DIRECT-INVERSE METHOD FOR TRANSONIC AND SEPARATED FLOWS ABOUT AIRFOILS Final Report**

L. A. CARLSON Dec. 1985 80 p refs
(Contract NSG-1174)
(NASA-CR-176403; NAS 1.26:176403; TAMRF-3224-85-12)
Avail: NTIS HC A05/MF A01 CSCL 01A

A direct-inverse technique and computer program called TAMSEP that can be sued for the analysis of the flow about airfoils at subsonic and low transonic freestream velocities is presented. The method is based upon a direct-inverse nonconservative full potential inviscid method, a Thwaites laminar boundary layer technique, and the Barnwell turbulent momentum integral scheme; and it is formulated using Cartesian coordinates. Since the method utilizes inverse boundary conditions in regions of separated flow, it is suitable for predicing the flowfield about airfoils having trailing edge separated flow under high lift conditions. Comparisons with experimental data indicate that the method should be a useful tool for applied aerodynamic analyses. Author

**N86-13301#** Royal Aircraft Establishment, Farnborough (England).

**STUDIES OF THE FLOW FIELD NEAR A NACA 4412 AEROFOIL AT NEARLY MAXIMUM LIFT**

R. C. HASTINGS and B. R. WILLIAMS Dec. 1984 35 p
(AD-A157750; RAE-TM-AERO-2026; DRIC-BR-96009) Avail: NTIS HC A03/MF A01 CSCL 02D

Measurements made at a Mach number of 0.18 and a chord-based Reynolds number of 4.2 x million on a constant-chord model having a NACA 4412 aerofoil section are described and compared with the results of flow field calculations. Both the experimental arrangement and the difficulties initially experienced in achieving an adequate approximation to two-dimensional flow above the wing are briefly outlined. The measurements include static pressure distributions on the wing surface and on the wind tunnel walls above and below the mid-span section of the wing. The main emphasis in the experiment was, however, on defining the development of the upper surface boundary layer through separation (at about 20% chord ahead of the trailing-edge) and on into the wake, making extensive use of laser anemometry. The flow field calculations are the semi-inverse kind in which an inverse momentum-integral treatment of the shear flow, used to avoid difficulties at separation, is coupled to a direct solution of the inviscid flow problem. The main features of the method are outlined. GRA

**N86-13302#** Royal Aircraft Establishment, Bedford (England).

**RECENT EXPERIENCE IN THE RAE (ROYAL AIRCRAFT ESTABLISHMENT) 5-METRE WIND TUNNEL OF A CHINA CLAY METHOD FOR INDICATING BOUNDARY LAYER TRANSITION**

I. R. M. MOIR Aug. 1984 11 p
(AD-A157943; RAE-TM-AERO-2007; DRIC-BR-94478) Avail: NTIS HC A02/MF A01 CSCL 14B

The china clay method is based on the differential rate of evaporation, beneath laminar and turbulent boundary layers, of a liquid absorbed on a solid spread on the surface. The liquid is chosen to have a similar refractive index to the solid so that the mixture appears to be transparent until evaporation has taken place, when the color of the solid becomes visible. The solid layer consists of china clay powder mixture with certain chemicals to form a lacquer, which is sprayed onto the surface. When dry, this forms a semi-permanent white absorbent film. A suitable liquid sprayed on to this film is absorbed by it, causing it to become transparent. Details of a visual method for indicating boundary layer transition are given, with particular reference to tests at high Reynolds number in the RAE 5-meter pressurized low-speed wind tunnel on a slender-body model. The method is compared with other techniques on the basis of ease of use and quality of the indication. GRA

**N86-13303#** Institut de Mecanique des Fluides de Lille (France).
**STUDY OF THE INFLUENCE OF AN OSCILLATING SPOILER ON THE SURROUNDING AERODYNAMIC FIELD [ETUDE DE L'INFLUENCE D'UNE PROTUBERANCE DE PAROI OSCILLANTE SUR LE CHAMP AERODYNAMIQUE ENVIRONNANT]**
O. RODRIGUEZ and J. M. DESSE 12 Nov. 1984 69 p refs In FRENCH
(Contract DRET-83-250)
(IMFL-3119) Avail: NTIS HC A04/MF A01

Transonic wind tunnel tests were carried out on a wall protuberance vibrating with sinudoidal oscillations. The experiments studied spoiler efficiency. The unsteady phenomena following the sinusoidal excitation were studied by ultrafast visualization and by unsteady pressure measurement on the obstacle. The free stream Mach number was 0.5. Spectrum analysis proves the nonlinear nature of the flow. The dimension of the separated flow region varies with the position of the spoiler on the body. The results show that at the frequences considered the response to the oscillations can be studied in steady flow tests. Author (ESA)

**N86-13304*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**PRESSURE-DISTRIBUTION MEASUREMENTS ON A TRANSONIC LOW-ASPECT RATIO WING**
E. R. KEENER Sep. 1985 77 p refs
(NASA-TM-86683; REPT-85131; NAS 1.15:86683) Avail: NTIS HC A05/MF A01 CSCL 01A

Experimental surface pressure distributions and oil flow photographs are presented for a 0.90 m semispan model of NASA/Lockheed Wing C, a generic transonic, supercritical, low aspect ratio, highly 3-dimensional configuration. This wing was tested at the design angle of attack of 5 deg over a Mach number range from 0.25 to 0.96, and a Reynolds number range from 3.4 x 1,000,000 to 10 x 1,000,000. Pressures were measured with both the tunnel floor and ceiling suction slots open for most of the tests but taped closed for some tests to simulate solid walls. A comparison is made with the measured pressures from a small model in high Reynolds number facility and with predicted pressures using two three dimesional, transonic full potential flow wing codes: design code FLO22 (nonconservative) and TWING code (conservative). At the given design condition, a small region of flow separation occurred. At a Mach number of 0.82 the flow was unseparated and the surface flow angles were less than 10 deg, indicating that the boundary layer flow was not 3-D. Evidence indicate that wings that are optimized for mild shock waves and mild pressure recovery gradients generally have small 3-D boundary layer flow at design conditions for unseparated flow. Author

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-13452**
**AIR TRAFFIC PREDICTION AND OPTIMAL CONTROL OF AIR TRANSPORTATION SYSTEM [PROGNOZIROVANIE AVIAPOTOKOV I OPTIMIZATSIIA UPRAVLENIIA VOZDUSHNOI TRANSPORTNOI SISTEMOI]**
R. G. LEONTEV Moscow, Izdatel'stvo Nauka, 1984, 184 p. In Russian. refs

The theoretical and practical methods of the planning and optimization of the transportation of passengers by air are reviewed, as are the planning of airport networks and the regional planning of civil aviation facilities. In particular, attention is given to the selection of the most efficient numerical methods of problem solving, the formulation of optimization criteria, and the development of computational algorithms and computer software. V.L.

**A86-14237*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**GROUND-SIMULATION INVESTIGATION OF VTOL AIRWORTHINESS CRITERIA FOR TERMINAL AREA OPERATIONS**
J. V. LEBACQZ (NASA, Ames Research Center, Moffett Field, CA) and B. C. SCOTT (FAA, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 761-767. Previously cited in issue 20, p. 2849, Accession no. A84-42353. refs

**A86-14427*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**ICE SHAPES AND THE RESULTING DRAG INCREASE FOR A NACA 0012 AIRFOIL**
W. OLSEN, R. SHAW, and J. NEWTON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 22nd, Reno, NV, Jan. 9-12, 1984. 30 p. Previously announced in STAR as N85-27839. refs
(AIAA PAPER 84-0109)

Experimental measurements of the ice shapes and resulting drag increases were measured in the NASA-Lewis Icing Research Tunnel. The measurements were made over a large range of conditions (e.g., airspeed and temperature, drop size and liquid water content of the cloud, and the angle of attack of the airfoil). The measured drag increase did not agree with the existing correlation. Additional results were given which are helpful in understanding the ice structure and the way it forms, and in improving the ice accretion modeling theories. There are data on the ice surface roughness, on the effect of the ice shape on the local droplet catch, and on the relative importance of various parts of the ice shape on the drag increase. Experimental repeatability is also discussed. Author

**A86-15306**
**RESPONSE DETERMINATION OF PROPELLER TO BIRD STRIKE USING HIGH SPEED PHOTOGRAPHY**
R. S. BERTKE (Dayton, University, OH) and R. L. EDINGER (TRW, Inc., Hartzell Propeller Products Div., Piqua, OH) IN: High speed photography, videography, and photonics II; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 4-8.

Static bench type impact tests of 4.0 and 1.5 pound artificial birds striking the leading edge of composite propeller blades are conducted to determine the damage response of the blades to bird strike. The artificial birds (cylindrical in shape) are launched at velocities up to 900 ft/sec (275 m/sec) to demonstrate that composite construction propeller blades will pass the Federal Aviation Administration (FAA) bird strike requirements. A high speed framing camera is used to determine the impact velocity of the birds, maximum tip deflections, bird/blade contact time, and the elapsed time required to achieve maximum deflection. Author

**N86-12212*#** Bolt, Beranek, and Newman, Inc., Cambridge, Mass.
**AN ANALYSIS OF THE APPLICATION OF AI TO THE DEVELOPMENT OF INTELLIGENT AIDS FOR FLIGHT CREW TASKS**
S. BARON and C. FEEHRER Washington NASA Oct. 1985 114 p refs
(Contract NAS1-17335)
(NASA-CR-3944; NAS 1.26:3944) Avail: NTIS HC A06/MF A01 CSCL 05H

This report presents the results of a study aimed at developing a basis for applying artificial intelligence to the flight deck environment of commercial transport aircraft. In particular, the study was comprised of four tasks: (1) analysis of flight crew tasks, (2) survey of the state-of-the-art of relevant artificial intelligence areas, (3) identification of human factors issues relevant to intelligent cockpit aids, and (4) identification of artificial intelligence areas requiring further research. Author

**N86-12213#** Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
**G PROTECTION BY AN EXTREME CROUCH POSITION Phase Report, 1 Aug. 1983 - 1 Sep. 1984**
H. J. VONBECKH 4 Sep. 1984 14 p
(Contract NR PROJ. F58-523)
(AD-A157081; NADC-84162-60) Avail: NTIS HC A02/MF A01 CSCL 06S

In World War II the pilots of diving bombers tolerated high G loads by assuming a crouch position. The Dynamic Flight Simulator (Human Centrifuge) was used to prove the advantages of the crouch position. Two subjects were located in an extreme crouch position, the upper spine being at an angle of 80 to 90 degrees from the vertical. They tolerated 6.5 and 7.5 G respectively. Both subjects have tolerated only 3.5 G in former experiments when seated upright. The use of an Anti-G suit did not improve further G tolerance. Both subjects abandoned the experiment not because of the Loss of Vision, but because of the discomfort of overfilling of the facial area with blood. It is planned to find a crouch position where the vision is still maintained and the blood filling of the facial area is mitigated. This would probably be a crouch position of 45 to 60 degrees from the vertical. Author (GRA)

**N86-12214#** Federal Aviation Agency, Atlantic City, N.J.
**AIRCRAFT INTERIOR PANEL TEST CRITERIA DERIVED FROM FULL-SCALE FIRE TESTS Final Report**
R. G. HILL, T. I. EKLUND, and C. P. SARKOS Sep. 1985 65 p refs Original contains color illustrations
(FAA/CT-85/23) Avail: NTIS HC A04/MF A01

Full scale cabin fire tests were conducted to determine potential increases in passenger survivability associated with different interior honeycomb panel constructions. The test fuselage was a C-133 with a simulated wide body door opening exposed to an 8 foot by 10 foot fuel fire. In the first series, the interior near the door was lined with the honeycomb panels to determine whether earlier studies performed with small scale enclosures were consistent with the full scale counterpart. These earlier studies resulted in the selection of the Ohio State University (OSU) Rate of Heat Release Apparatus as the most appropriate type test to evaluate aircraft panels. The first series was followed by tests that included fire blocked seats and carpeting as well as the panels to determine the type survivability increases that could be attained from low heat release materials. The scenario employed generally resulted with flashover within 2 minutes for panels considered typical in performance. A low heat release phenolic/fiberglass panel demonstrated a flashover delay until about 4 minutes into the test. An incombustible panel prevented flashover altogether. The performance of the various panels was evaluated to develop recommended flammability criteria for a modified OSU Rate of Heat Release Apparatus. Author

**N86-12215#** General Accounting Office, Washington, D. C. Resources Community and Economic Development Div.
**FAA (FEDERAL AVIATION ADMINISTRATION) COULD IMPROVE OVERALL AVIATION SAFETY AND REDUCE COSTS ASSOCIATED WITH AIRPORT INSTRUMENT LANDING SYSTEMS**
3 Apr. 1985 50 p
(PB85-195444; GAO/RCED-85-24; B-215115) Avail: NTIS HC A03/MF A01 CSCL 01E

The Federal Aviation Administration (FAA) operates and maintains over 700 instrument landing systems at airports throughout the United States. The Government Accounting Office (GAO) found that FAA could save about $31 million between now and the year 2000 if it replaced some of its older instrument landing systems with newer systems, which are less costly to operate. GAO also found that FAA could improve overall aviation safety and reduce cost by ensuring that existing systems are located where they are needed most. GRA

**N86-13305*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**ADVANCED EMERGENCY OPENINGS FOR COMMERCIAL AIRCRAFT**
L. J. BEMENT and M. L. SCHIMMEL Nov. 1985 18 p refs Presented at the 30th Corporate Aviation Safety Seminar, Dallas, Texas, 14-16 Apr. 1985
(NASA-TM-87580; L-16012; NAS 1.15:87580) Avail: NTIS HC A02/MF A01 CSCL 01C

Explosively actuated openings in composite panels are proposed to enhance passenger survivability within commercial aircraft by providing improvements in emergency openings, fuselage venting, and fuel dump. The concept is to embed a tiny, highly stable explosive cord in the periphery of a load-carrying composite panel; on initiation of the cord, the panel is fractured to create a well-defined opening. The panel would be installed in the sides of the fuselage for passenger egress, in the top of the fuselage for smoke venting, and in the bottoms of the fuel cells for fuel dump. Described are the concerns with the use of explosive systems, safety improvements, advantages, experimental results, and recommended approach to gain acceptance and develop this concept. Author

**N86-13306*** Ecosystems International, Inc., Crofton, Md.
**NASA FLIGHT OPERATIONS REVIEW Final Report**
Sep. 1985 113 p Sponsored by NASA
(NASA-CR-176393; NAS 1.26:176393) Avail: Issuing Activity CSCL 01C

Independent assessments of the provisions taken by NASA to assure the safety of their aviation operations are reported. Aviation operations conducted at the Lewis Research Center (LeRC) are reviewed. These reviews and independent assessments were undertaken as part of an on-going effort to provide NASA management with a qualitative evaluation of the overall organizational structure, administrative policy. A report which provides NASA management with a broad overview of the current status and safety of aviation operations at LeRC is presented. Recommendations for improvements are provided whenever a significant impact on the present level of safety assurance is judged to be feasible, or an existing situation has the potential for creating a hazardous condition. E.A.K.

**N86-13307#** Department of the Navy, Washington, D. C.
**PASSIVE ARM RETENTION CURTAIN Patent Application**
T. J. ZENOBI, inventor (to Navy) 2 Nov. 1984 12 p
(AD-D011876; US-PATENT-APPL-SN-667685) Avail: NTIS HC A02/MF A01 CSCL 01C

A pilot arm retention system for an aircraft ejection seat which includes inertia reels and a parachute is comprised of a pair of nets connected between respective sides of the seat and a pair of deployment straps which are releasably coupled to the inertia reel straps and parachute risers and routed down over the front of the seat through a pair of snubbers to fixed points on the cockpit floor. Author (GRA)

**N86-13308#** Institut de Mecanique des Fluides de Lille (France).
**AIRCRAFT CRASHING. ANALYSIS AND IDENTIFICATION METHODS. PRESENTATION OF A SOLUTION METHOD [CRASH D'AVIONS. METHODES D'ANALYSE ET D'IDENTIFICATION. PRESENTATION D'UNE METHODOLOGIE DE RESOLUTION]**
P. GEOFFROY and E. HAUG (ESI SA) 19 Feb. 1985 102 p refs In FRENCH
(Contract DRET-83-452)
(IMFL-4116) Avail: NTIS HC A06/MF A01

An aircraft landing crash with a vertical velocity 5 m/sec is discussed. The tail section is assumed to make first contact. The nonlinear aspect of the problem is emphasized and a numerical solution is worked out. Superelements methods are found to be best suited to the problem. They conserve existing programs and finite element computations. An identification method is used to adjust the physical parameters in the superelements. The implementation of these techniques in the NL-CRASH program is proposed. Author (ESA)

**N86-13617#** Joint Publications Research Service, Arlington, Va.
**CERTIFICATION GRANTED TO FRANCO-ITALIAN ATR 42**
*In its* West Europe Rept.: Sci. and Technol. (JPRS-WST-85-031) p 10-13 8 Nov. 1985 Repr. from Rev. Aerospatiale (France), Oct. 1985 p 10; 12
Avail: NTIS HC A03/MF A01

The Franco-Italian (Aerospatiale/Aeritalia) ATR-42 commercial aircraft has been granted certification. The first production model was to be delivered in November 1985. The joint European venture expects to capture a generous share of the expected market (into the year 2000) of 2200 thirty-fifty and over 100 fifty-seventy passenger aircraft. F.M.R.

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-12677**
**USING ROLL-ANGLE MEASUREMENTS TO TRACK AIRCRAFT MANEUVERS**
C. C. LEFAS (Ministry of Physical Planning, Housing, and Environment, Athens, Greece) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-20, Nov. 1984, p. 672-681. Research supported by Eurocontrol. refs

Present day radar trackers used for air traffic control purposes perform satisfactorily during straight-line flight, but their performance during maneuvers is sometimes degraded. The introduction of the secondary surveillance radar mode S system makes transmission of several airborne measurements to the ground station possible. This paper investigates the use of one such parameter, roll angle, to assist present trackers during maneuvers to achieve accuracies comparable to those achieved during straight-line flight. Author

**A86-12698*#** National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
**ELT ANTENNA GAIN DISTRIBUTIONS UNDER SIMULATED CRASH CONDITIONS**
H. ESTEP (NASA, Goddard Space Flight Center, Greenbelt, MD) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-20, Nov. 1984, p. 841-843.

A study of the relative merits of ELT antenna positions, when mounted on a small aircraft, is presented. The gain distribution of the best antenna position together with the worst crash scenario is also given. Author

**A86-13216**
**THE RAJPO GPS RANGE EQUIPMENT FAMILY**
D. L. HOLEMAN and E. G. BLACKWELL (SRI International, Menlo Park, CA) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 173-181.

Equipment that is to be developed by the Global Positioning System (GPS) Range Applications Joint Program Office (RAJPO) for use on test and training ranges is discussed. The purpose of the tri-service program is to develop a family of modules that can be assembled to provide GPS time-space position-information determination functions. The RAJPO is sponsoring development of specific configurations of the equipment to demonstrate GPS integration concepts on several existing and planned range systems, including the Army Mobile Automated Field Instrumentation System (MAFIS) at Fort Hood, the Air Force Gulf Range Drone Control Upgrade System (GRDCUS) at Tyndall AFB, the Navy Extended Area Test System (EATS) at the Pacific Missile Test Center, the Air Force Advanced Range Data System (ARDS) at Edwards AFB, and the Navy/Air Force Tactical Aircrew Combat Training System/Air Combat Maneuvering Instrumentation (TACTS/ACMI) at a location to be determined. D.H.

**A86-13217**
**CORRELATION OF GPS RECEIVER CHANNEL TRACK CONTINUITY WITH AIRCRAFT STRUCTURAL MASKING**
E. G. BLACKWELL, E. T. FICKAS, and D. Y. RICHARDSON (SRI International, Menlo Park, CA) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 189-197.
(Contract DAEA18-81-G-0062)

A GPS receiver with antennas located in an aircraft-mounted pod will be subject to signal blockage due to masking of the GPS satellite constellation by the aircraft structure. Analysis of aircraft flight test data involving a wing-mounted GPS antenna has shown that most of the receiver's loss-of-lock occurrences can be correlated with the optical shadow of the aircraft. Shadow regions of various tactical aircraft are used to estimate the extent of tracking outages for GPS pod antennas with the full 18-satellite constellation. Author

**A86-13224**
**AN OVER THE HORIZON COMMAND/DATA LINK SYSTEM**
W. C. TURNER (Electro Magnetic Processes, Inc., Chatsworth, CA) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 327-340.

A three channel link, L-band, MDI band, and S-band, over which command, television, and telemetry are transmitted over a 100 mile range is discussed. A general description and diagram of the over the horizon command/data link system utilizing a three channel link is presented. The components and functions of the shore station, aircraft repeater station, and ship's station are described. Range altitude coverage profiles for the shore station and ship's station, revealing the range of each antenna, are provided. Techniques for determining antenna selection and location, and the selection of link transmitter power and system noise figure to achieve a carrier-to-noise ratio of ratio of 12dB or greater are analyzed. Link budgets for two paths of the over-the-horizon relay link are given. Design parameters for an over the horizon microwave link are listed. I.F.

**A86-13225**
**AIRBORNE TELEMETRY - THE ADVANCED RANGE INSTRUMENTATION AIRCRAFT**
L. G. AVERY, JR. (USAF, ARIA Programs Div., Wright-Patterson AFB, OH) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 341-347.

The ARIA which tracks and obtains telemetry data to support lunar missions, orbital vehicles, and ballistic and cruise missiles with nonreal-time and real-time coverage is discussed. The ARIA contains a 30,000 pound modular package of instrumentation subsystems, Prime Mission Electronic Equipment (PMEE). The functions of the antenna, radio frequency, record, timing, communications, and data separation subsystems and the master control console of PMEE are described. Improvements in the PMEE, and cruise missile, Pershing II, and airframe modifications are examined. Proposed modifications to the ARIA fleet include: the use of C-18 airframes; a cruise missile mission control aircraft; an advanced medium-range air-to-air missile; and a sonobuoy missile impact location system. I.F.

**A86-13226**
**AN INTEGRATED SOLUTION FOR FLIGHT TEST DATA HANDLING**
W. E. DUNN (Fairchild Weston Systems, Inc., Sarasota, FL) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 349-362.

An integrated airborne/ground data acquisition and processing system is being implemented for McClellan AFB. This Flight Data Acquisition and Processing System is capable of gathering large amounts of varied types of instrumentation data during F-111 test flights and providing general purpose computer processing of the test data results. A programmable PCM data acquisition system was developed along with companion acquisition systems for monitoring the F-111 SRAM, MARK II, PAVETACK, and MIL-STD-1553 on board computer busses. The information is stored on an IRIG instrumentation recorder for subsequent processing and display by a DEC VAX 11/780 computer in the ground station. The VAX in the ground station is supported by multiple programmable preprocessors for data compression/engineering unit conversion and a specially developed software system provides a unique integration of the airborne/ground system capabilities via a parameter data base. A special capability of the system is the ability to process a typical flight tape utilizing a single playback of the instrumentation tape at the recorded speed. Author

**A86-13227**
**AN EXTENDED PHASE-LOCK TECHNIQUE FOR AIDED ACQUISITION**
S. BARBOUR (Figgie International, Inc., Hartman Systems Div., Huntington Station, NY) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 363-370.

A novel approach is described to extend the threshold for a phase-locked loop designed for a particular telemetry receiver. By phase remodulating the error signal, the network reduces the phase swing of the signal and restores the carrier power so as to provide anti-sideband properties for biphase and PM modulation up to 1.3 radians deviation at all modulation frequencies and at a signal level where CNR is greater than 5 dB above PM threshold. D.H.

**A86-13230**
**THE USE OF TRANSLATORS WITH GPS**
E. E. WESTERFIELD (Johns Hopkins University, Laurel, MD) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 391-396.

An alternative approach is described that can obviate putting expensive receivers onboard expendable platforms to use the Air Force Global Positioning System (GPS) for position and velocity determination. If either a translator or a transdigitizer is used in the vehicle under test, signals transmitted by GPS satellites are received by vehicle antennas, translated to a frequency in the telemetry band, amplified, and transmitted to a receiving station. Specially designed receiving equipment on the ground processes the transmissions from the translator/transdigitizer, tracks the transmissions from each satellite, and makes the measurements necessary to allow computation of the platform position and velocity. Systems concepts are discussed and two current systems - one using a translator in a missile and the other a transdigitizer in a sonobuoy - are described in detail. D.H.

**A86-13576**
**REQUIREMENTS FOR GYROSCOPES FOR INERTIAL NAVIGATION**
J. D. NUTTALL (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IEE Proceedings, Part J - Optoelectronics (ISSN 0267-3932), vol. 132, pt. J, no. 5, Oct. 1985, p. 250-254.

Work regarding the fiber-optic rotation sensor is now proceeding at an estimated forty or fifty institutions in the UK, U.S., and Western Europe. Many of the institutions have had no previous experience of rotation sensors (or gyroscopes, as they are traditionally called), while some workers in the field have little idea of the current state-of-the-art of mechanical ('spinning mass') gyros and ring laser gyros (RLGs). It is pointed out that this paper is intended as a briefing for such people, taking into account the performance needed from a gyroscope suitable for use in inertial navigation today. The gimballed and strapdown systems of inertial navigation are discussed along with the use of a gyroscope for north finding, the operation of gyros with and without torquers, requirements on maximum detectable rotation rate, requirements on scale factor accuracy, gyro drift or bias, and some examples of real gyros. G.R.

**N86-12216*#** Ohio State Univ., Columbus. ElectroScience Lab.
**SIMULATION OF THE ENHANCED TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS 2) Semiannual Report**
R. G. ROJAS, W. D. BURNSIDE, P. LAW, and B. GRANDCHAMP Sep. 1985 86 p refs
(Contract NSG-1498)
(NASA-CR-176328; NAS 1.26:176328; SAR-716199-3) Avail: NTIS HC A05/MF A01 CSCL 17G

The OSU aircraft code is used to analyze and simulate the TCAS 2 circular array which is mounted on the fuselage of a Boeing 737 aircraft. It is shown that the sum and difference patterns radiated by the circular array are distorted by the various structures of the aircraft, i.e., wings, tail, etc. Furthermore, monopulse curves are calculated and plotted for several beam positions and THETA angles. As expected, the worst cases of distortion occur when the beams are pointed toward the tail of the aircraft. Author

**N86-13309#** Aeronautical Research Labs., Melbourne (Australia).
**AN ANALYTICAL COMPARISON OF THREE VISUAL APPROACH SLOPE INDICATORS: VASIS, T-VASIS AND PAPI**
J. MILLAR Aug. 1984 56 p refs Original contains color illustrations
(ARL/SYS-R-33; AR-003-963; SR-33) Avail: NTIS HC A04/MF A01

The three Visual Approach Slope Indicators (VASIs), VASIS, T-VASIS and PAPI, approved by the international Civil Aviation Organization (ICAO) for use by turbojet aeroplanes are compared. The discussion is based upon published performance data including approach path measurements and pilot opinion, ergonomics and the ability to fulfill operational requirements. It is concluded from flight trial data and operational experience that T-VASIS is a more precise and sensitive aid than Red-White VASIS which has several deficiencies. The current policy of not using Red-White VASIS for routine operations in Australia is supported by the conclusions. It is predicted that PAPI also will be less satisfactory than T-VASIS. This prediction is based mainly on ergonomic principles. Performance data about PAPI is limited and consists mainly of relatively uninformative pilot acceptance surveys. Because insufficient objective parameters describing trajectories of aircraft from the intended user-population have been published, most of the claims for PAPI superiority remain unsubstantiated. Accordingly, it is recommended that PAPI be evaluated using objective measures in a controlled experimental environment with transport aircraft. Author

**N86-13310*#** Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
**THE EVALUATION OF FAILURE DETECTION AND ISOLATION ALGORITHMS FOR RESTRUCTURABLE CONTROL Interim Report, Dec. 1983 - May 1984**
P. MOTYKA, W. BONNICE, S. HALL, and E. WAGNER Aug. 1984 207 p refs
(Contract NAS1-17556)
(NASA-CR-177983; NAS 1.26:177983; CSDL-R-1799) Avail: NTIS HC A10/MF A01 CSCL 01C

Three failure detection and identification techniques were compared to determine their usefulness in detecting and isolating failures in an aircraft flight control system; excluding sensor and flight control computer failures. The algorithms considered were the detection filter, the Generalized Likelihood Ratio test and the Orthogonal Series Generalized Likelihood Ratio test. A modification to the basic detection filter is also considered which uses secondary filtering of the residuals to produce unidirectional failure signals. The algorithms were evaluated by testing their ability to detect and isolate control surface failures in a nonlinear simulation of a C-130 aircraft. It was found that failures of some aircraft controls are difficult to distinguish because they have a similar effect on the dynamics of the vehicle. Quantitative measures for evaluating the distinguishability of failures are considered. A system monitoring strategy for implementing the failure detection and identification techniques was considered. This strategy identified the mix of direct measurement of failures versus the computation of failure necessary for implementation of the technology in an aircraft system. Author

**N86-13311*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**DISCOVERY OF THE KALMAN FILTER AS A PRACTICAL TOOL FOR AEROSPACE AND INDUSTRY**
L. A. MCGEE and S. F. SCHMIDT Nov. 1985 24 p refs
(NASA-TM-86847; REPT-85424; NAS 1.15:86847) Avail: NTIS HC A02/MF A01 CSCL 17G

The sequence of events which led the researchers at Ames Research Center to the early discovery of the Kalman filter shortly after its introduction into the literature is recounted. The scientific breakthroughs and reformulations that were necessary to transform Kalman's work into a useful tool for a specific aerospace application are described. The resulting extended Kalman filter, as it is now known, is often still referred to simply as the Kalman filter. As the filter's use gained in popularity in the scientific community, the problems of implementation on small spaceborne and airborne computers led to a square-root formulation of the filter to overcome numerical difficulties associated with computer word length. The work that led to this new formulation is also discussed, including the first airborne computer implementation and flight test. Since then the applications of the extended and square-root formulations of the Kalman filter have grown rapidly throughout the aerospace industry. Author

**N86-13312#** National Airspace System Program Office, Washington, D.C.
**NATIONAL AIRSPACE SYSTEM, SYSTEM REQUIREMENTS SPECIFICATION**
21 Mar. 1985 209 p
(AD-A157944; NAS-SR-1000) Avail: NTIS HC A10/MF A01 CSCL 01E

The NAS System Requirements Specification (NASSRS) is a compilation of requirements which describe the operational capabilities for the National Airspace System (NAS) as the NAS is envisioned to exist by the year 1995. In that context, it includes those existing and transitional capabilities that will also exist in the 1995 system. It is intended primarily for use as an internal FAA management tool to support the NAS design, engineering, and acquisition activities and to manage and control change to the NAS. The document provides a ground-based systems representation of the proposed operational capabilities planned for the NAS. As programs and subsystems are developed and implemented the capabilities they provide will be compared to this document as a measure of success of NAS Plan Implementation. The contents of the document include: overview; flight planning; traffic control and airspace management; monitoring; navigation; air defense and law enforcement surveillance; aircraft detection and identification; communications; maintenance and support: system effectiveness. GRA

**N86-13314#** Army Construction Engineering Research Lab., Champaign, Ill.
**DESIGN CRITERIA UPGRADE FOR US ARMY TYPE 2 AIR TRAFFIC CONTROL TOWERS Final Report**
T. R. NAPIER, W. E. BACK, and M. MCCULLEY Jun. 1985 72 p
(AD-A159115; CERL-TR-P-85/13) Avail: NTIS HC A04/MF A01 CSCL 17G

This report documents research conducted to identify problem areas in; the design of existing Type 2 Air Traffic Control Tower (ATCT) installations and to develop standard design criteria to avoid these problems in future installations. Many design problem areas were identified in the ATCT structure's architectural design, substructure, superstructure, roof systems, exterior walls, interior construction, mechanical systems, electrical systems, and air traffic control interfaces. For each of these areas, specific solutions to the problems were recommended. However, incorporation of these solutions must consider a specific site location and environmental conditions. GRA

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-13052#**
**F-4 FUNCTIONAL MODERNIZATION**
W. D. POULIN (United Technologies Corp., Government Products Div., West Palm Beach, FL) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 815-820.
(ASME PAPER 85-GT-69)

Attention is given to the F-4 'Super Phantom' as an exemplary case of the functional modernization of an existing aircraft, as an alternative to the more expensive acquisition of new types. The F-4 modernization package considered in the present feasibility study encompasses a novel centerline (conformal) fuel tank, digital avionics, and PW1120 reengining for greater thrust. The reengining, in particular, leads to a 1:1 thrust-to-weight ratio, which is deemed capable of sustaining fighter survivability against threats anticipated through the 1990s. The performance levels obtained are comparable to those of the most recent fighter designs, at less than half the cost. O.C.

**A86-13106**
**STRUCTURAL BONDING WITH POLYSULFIDE ADHESIVE ON B-1B AIRCRAFT**
J. FASOLD (Rockwell International Corp., Columbus, OH) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 461-470.

A novel technique has been developed for the bonding of composite antiicing blankets to directionalizing vanes that are located inside the nacelle ducts of the B-1B aircraft. The selection of the adhesive system was based on the ability of the adhesive to allow removal of the blankets from the vane if necessary, while retaining the bond in the severe load spectrum created by the nacelle inlet's vibroacoustic environment. A 100-percent solids polysulfide adhesive was selected on the basis of trade studies, while structural films and pastes were rejected. O.C.

**A86-13127**

**THE USE OF AUTOMATED RIVETING SYSTEMS IN AIRCRAFT CONSTRUCTION**

J. MASKOW (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 855-863.

A riveting system has been developed for spherical surface airframe structures that is fully automated, using an optical sensor which automatically compensates for dimensional variations through adjustment of component tolerances. Also developed is a riveting system for the assembly of clip-to-frame connections which employs a numerically controlled positioner with an optical sensor. These systems facilitate the manufacture of longitudinal joint connections on closed aircraft fuselages. O.C.

**A86-13213**

**X-29 FLIGHT TESTING**

D. SANGL (Grumman Data Systems Corp., Bethpage, NY) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 139-146.

Attention is given to the methods used to achieve real time flight test monitoring of the NASA X-29 forward swept wing research aircraft, such that flight test analysts and design engineers in Bethpage, NY, were privy to aircraft behavior during flight testing in California. The X-29's telemetry data is PCM at 500 kb/sec, and beamed at a geosynchronous satellite. A transponder channel receives this beam and retransmits it on an antenna that covers most of the U.S. An earth station system at Calverton, NY, receives this signal and regenerates the aircraft PCM signal through a modem. O.C.

**A86-13219**

**TELEMETRY FROM EXPERIMENTAL RESCUE- AND RECOVERY SYSTEMS**

H.-J. KLEWE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 217-224. refs

Measuring techniques in rescue and recovery systems are mainly applied to parachute and ejection seat systems. Thereby, the measurements of special interest are forces occurring in the suspension lines of parachutes during inflation; accelerations acting on persons to be rescued or on materials to be recovered; the progress of velocities during the retarding of persons, ejection seats, test vehicles and so on; as well as measurements of the static pressure and possibly the outside temperature for the determination of altitudes. Further, the change of the projected area of a parachute during inflation will also be of interest. The data values are transformed by the transducers to analogue electric signals and telemetered to the ground station. To determine the projected area of the parachute during inflation this event is filmed by a high speed film camera which is installed in the rear of the test vehicle. Furthermore, the entire experiment is filmed from the ground by another high speed camera. On request, a cinetheodolite and a tracking radar installation is used additionally to get data concerning rate of descent and trajectory of the parachute-load system. Author

**A86-13264**

**THE INFLUENCE OF ADVANCED PROPULSION ON SHORT-TO MEDIUM-RANGE TRANSPORT DESIGN**

G. E. LEDBETTER (Boeing Commercial Airplane Co., Seattle, WA) Aerospace (UK) (ISSN 0305-0831), vol. 12, Oct. 1985, p. 30-32.

The effect of advanced propulsion and improved wings on the design of passenger transport aircraft is examined. A comparison of the effects of bypass ratio on the weight and thrust specific fuel consumption of turbofan and turboprop aircraft with engine cruise thrust of 4000 pounds at M = 0.75 at 3500 ft is presented; the high-speed turboprop is predicted to save 27 percent more fuel than the turbofan. An experiment evaluating the fuel efficiency of six 150-passenger transport aircraft at M = 7.5 at 35,000 ft with a design range of 1700 n mi and wing-mounted or aft-mounted engines, and various wing aspect ratios is described and a graph is provided. The results reveal the improved efficiency of the turboprop over the turbofan for each wing configuration. I.F.

**A86-13275**

**MODELING REALISTIC ENVIRONMENTAL STRESSES ON EXTERNAL STORES**

H. W. ALLEN (LTV Aerospace and Defense Co., Dallas, TX) Journal of Environmental Sciences (ISSN 0022-0906), vol. 28, Sept.-Oct. 1985, p. 26-33. refs

This paper presents a method for achieving realism required by recent DOD tailoring documents. Use of this approach can be cost-effective for modeling realistic external-store environmental vibration stresses, where no measured data is available. The emphasis presented herein is in tailoring vibration levels to actual mission-defined captive and free-flight profiles. This approach uses a 'maximum predicted environment' derived from the statistical analyses of 1839 random vibration flight data measurements made on six different external stores. The basic vibration data used in these analyses were measured on six different host aircraft under a wide variety of captive flight conditions. In comparison, the MIL-STD-810D calculated qualification test requirement for an aft-half, MER cluster, air-to-air missile, produced a required testing level greater than twice the maximum predicted environment (overall grms level) for an equivalent missile. Author

**A86-13315#**

**STRAIN MEASUREMENT OF THE USB-FLAP STRUCTURES OF NAL STOL AIRCRAFT**

K. EGAWA and M. SANO (National Aerospace Laboratory, Chofu, Japan) IN: International Congress on Experimental Mechanics, 5th, Montreal, Canada, June 10-15, 1984, Proceedings . Brookfield Center, CT, SESA, 1984, p. 236-244. refs

A reversible strain gage was developed for strain measurements in the safety tests of the upper surface blowing type flap structures that are used as high lift devices in new STOL aircraft. The strain gage has a room-temperature curing adhesive on the reverse, allowing it to be used twice, and fulfills the requirements imposed on it by the acoustically excited conditions of the test. In particular, it (1) can be attached at the measuring points without heating to avoid deforming of the test panels, (2) attains more accuracy on the first test run, permitting conductance of one-shot tests, and (3) has high durability. The gage can be used at 150 C for about 110 hours. I.S.

**A86-13368**

**WING STRUCTURE DESIGN FOR MAXIMUM AILERON EFFICIENCY [PROEKTIROVANIE KONSTRUKTSII KRYLA IZ USLOVIIA MAKSIMIZATSII EFFEKTIVNOSTI ELERONOV]**

A. V. SHARANIUK and IU. F. IAREMCHUK TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 82-89. In Russian. refs

The objective of the study is to determine the effect of changes in the stiffness of the wing structure on the efficiency of ailerons. The gradient of the aileron efficiency function is determined by using the method of Lagrangian multipliers. A low-aspect-ratio wing is considered as an example, and the aileron efficiency gradient is calculated from the wing stiffness parameters for a constant total mass of the structure, with constraints imposed on the thickness of the isotropic and orthotropic panels and on the stiffness of the beams. V.L.

**A86-13369**

**EQUATIONS OF ROLLING FOR A WHEEL WITH AN ELASTIC TIRE [OB URAVNENIIAKH KACHENIIA KOLESA S UPRUGOI SHINOI]**

V. S. GOZDEK TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 90-99. In Russian. refs

The problem of the small oscillations of a rolling wheel with an elastic tire is formulated as a boundary value problem for a partial differential equation. A method is proposed for reducing this problem to a system of ordinary differential equations. A method is also proposed for deriving equations of rolling which approximately allow for the inertia of the deformable tire. V.L.

**A86-13371**

**CHARACTERISTICS OF THE LIFTING PROPERTIES OF AIRCRAFT WITH SWEPTFORWARD WINGS AT SUPERSONIC VELOCITIES [OSOBENNOSTI NESUSHCHIKH SVOISTV SAMOLETOV S KRYL'IAMI OBRATNOI STRELOVIDNOSTI PRI SVERKHZVUKOVYKH SKOROSTIAKH]**

A. A. GLADKOV and R. A. RATNER TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 109-113. In Russian. refs

The lifting force distributions over the elements of schematic aircraft configurations with swept and sweptforward wings are compared for the case of supersonic flow using the panel method. It is shown that the main difference between the two wing configurations consists in the body-wing interference pattern. It is further shown that the difference between the lifting properties of the two types of wings becomes less pronounced with increasing Mach numbers. V.L.

**A86-13421**

**ANALYTICAL METHOD FOR CONSIDERING THE ELASTICITY OF THE BLADES IN THE AERODYNAMIC CALCULATION OF A HELICOPTER PROPELLER [ANALITICHESKII METOD UCHETA UPRUGOSTI LOPASTEI V ZADACHE AERODINAMICHESKOGO RASCHETA NESUSHCHEGO VINTA VERTOLETA]**

V. S. VOZHDAEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 99-112. In Russian. refs

Approximate analytical solutions of the partial differential equations of the combined bending and torsional vibrations of a propeller blade are obtained along with instantaneous coefficients for the influence of circulations on the vertical displacements and elastic-twist angles of blade elements. These solutions are obtained on the basis of periodic solutions of second-order differential equations, reduced to integral operators transforming the input force excitation into the periodic response of the system. The problem thus becomes one of the aerodynamic calculation of an absolutely rigid propeller with allowance for the effect of elasticity in the influence-function matrix of induced velocities. B.J.

**A86-13437**

**DESIGN OF A MINIMUM-WEIGHT GLIDING WING [PROEKTIROVANIE SKOL'ZIASHCHEGO KRYLA MINIMAL'NOI MASSY]**

N. V. BANICHUK, V. I. BIRIUK, and I. I. KOANDE TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 71-76. In Russian.

The problem of the optimal distribution of the stiffness characteristics over the span of a gliding swept wing is solved according to a minimum-weight criterion. Constraints are imposed on the aerodynamic load-bearing capacity of the wing and on the difference of moments between cantilevers of the wing. The influence of different structural parameters on the optimal solution is examined. B.J.

**A86-13438**

**OPTIMIZATION OF STRUCTURAL LOAD-BEARING DESIGNS USING ANISOTROPIC MODELS ACCORDING TO AEROELASTICITY CONDITIONS [OPTIMIZATSIIA KONSTRUKTIVNO-SILOVYKH SKHEM PRI ISPOL'ZOVANII ANIZOTROPNYKH MODELEI PO USLOVIIAM AEROUPRUGOSTI]**

V. I. BIRIUK and A. V. SHARANIUK TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 77-84. In Russian. refs

The optimization of the structural load-bearing designs of wings according to aeroelasticity conditions using anisotropic models is considered. The wing panels are modeled as an orthotropic plate of variable stiffness; the optimal orientation angle of the anisotropy axes corresponding to the largest of the moduli is determined for this plate under the condition of the maximization of either the efficiency of the transverse-control elements or the critical flutter velocity (or divergence). Examples of the choice of the optimal orientation of the anisotropy axes for swept wings are presented. B.J.

**A86-14161**

**THRUST AND DRAG: ITS PREDICTION AND VERIFICATION**

E. E. COVERT, ED. (MIT, Cambridge, MA) New York, AIAA (Progress in Astronautics and Aeronautics. Volume 98), 1985, 358 p. No individual items are abstracted in this volume.

A survey and critical review of the state of the art in prediction and verification of thrust and drag of jet-propelled aircraft is presented. The subjects addressed include: thrust-drag accounting methodology, gas turbine engine performance determination, prediction and verification of aerodynamic drag, throttle-dependent forces, and precision and propagation of errors. A brief historic perspective on the estimation and prediction of drag and on the turbojet engine is also provided. C.D.

**A86-14245*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**POWERED-LIFT TECHNOLOGY ON THE THRESHOLD**

W. H. DECKERT and J. A. FRANKLIN (NASA, Ames Research Center, Moffett Field, CA) Aerospace America (ISSN 0740-722X), vol. 23, Nov. 1985, p. 34-38, 40, 42.

A design configuration study and comparative performance evaluation is presented for current and planned V/STOL military aircraft and their powerplant and control systems, with a view to the effect of the operational capabilities uniquely furnished by such aircraft for battlefield tactics. Attention is given to V/STOL naval aircraft and the carrier or ship's deck conditions under which they must be able to operate. Thrust-vectoring and tilt rotor configurations are the most prominent among successful experimental and operational aircraft of this type; cargo aircraft have most often incorporated short/rough airfield operation capabilities rather than full VTOL. A major development thrust has been mounted for a supersonic short takeoff/vertical landing aircraft. O.C.

**A86-14356#**

**THE IN-FLIGHT SIMULATION PROGRAM AT THE NAE FLIGHT RESEARCH LABORATORY**

M. SINCLAIR, M. MORGAN, and S. KERELIUK (National Aeronautical Establishment, Ottawa, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, June 1985, p. 116-124. refs

The Canadian National Aeronautical Establishment's In-Flight Simulator is an adaptable flight mechanics facility serving in a wide range of aircraft and flight system research roles relevant to V/STOL systems. Three specially instrumented airborne simulation helicopters are used in this research work, which has recently encompassed the testing of a multimode matrix display, pilot workload studies, the design and performance of multiaxis side-arm controllers, and helicopter instrument flight handling qualities. O.C.

**A86-14361**
**7J7 - BOEING SETS THE PACE**
J. MOXON Flight International (ISSN 0015-3710), vol. 128, Oct. 26, 1985, p. 24-28.

Attention is given to novel technologies' incorporation in the B-7J7 150-seat airliner, which is scheduled for delivery in 1992 and will feature the use of contrarotating unducted fan (UDF) powerplants. The UDF is expected to furnish the greater part of the 40-percent fuel efficiency improvement projected for the 7J7. Other advanced technologies will encompass fly-by-wire/fly-by-light controls with a direct optical link between sensors and controllers, a high speed data bus for cockpit, systems and computer communications, and aluminum-lithium alloy and graphite/epoxy primary structures. O.C.

**A86-14423**
**THE 'SUPER ETENDARD' IS ALWAYS OF INTEREST [LE 'SUPER ETENDARD' EST TOUJOURS D'ACTUALITE]**
J. MORISSET and R. NAZARETIAN Air et Cosmos (ISSN 0044-6971), vol. 23, Oct. 12, 1985, p. 21, 23, 24, 29. In French.

Plans are under way to produce another upgraded version of the Super Etendard (SE), which is an evolution of an aircraft first manufactured in 1956. The new versions are targeted for the defense of aircraft carriers. The selling points of the new SE are its recent successes as a low-level, maneuverable transonic attack aircraft. The upgrades include the Atar 8K50 engine for Mach 0.8 flight with over 10,000 lb thrust. Coomparisons of the SE with the new AMX show relative equivalence in many aspects. The SE will receive an advanced avionics system with automated navigation accurate to within 1 nm/hr. The cockpit will include HUD and flight phase controls. Other equipment are FLIR, ECM, and automated target acquisition and tracking. M.S.K.

**A86-14436#**
**AERO/PROPULSION TECHNOLOGY FOR STOL AND MANEUVER**
J. F. MELLO and D. R. KOTANSKY (McDonnell Aircraft Co., St. Louis, MO) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 10 p.
(AIAA PAPER 85-4013)

The expected benefits from the two-dimensional thrust vectoring the thrust reversing (TV/TR) nozzles and canards to be used on a F-16 fighter in a STOL and Maneuvering flight test program are delineated. Nozzle deflection furnishes STOL capabilities and roll, pitch and yaw control for the twin-engined F-15. Internal operations are maximized by controlling the exhaust aperture. TR can furnish up to 67 percent full reverse power in landing phases and in-flight. Dihedral canards increase lift in supersonic flight and provide positive trim, while aerodynamically reacting favorably with the wings, which are twice the length of the canards. The tests are hoped to yield effective design options for future fighter aircraft. M.S.K.

**A86-14449**
**THE DEVELOPMENT OF DYNAMIC PERFORMANCE STANDARDS FOR GENERAL AVIATION AIRCRAFT SEATS**
S. J. SOLTIS (FAA, Washington, DC) and J. W. OLCOTT (Business and Commercial Aviation, White Plains, NY) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 16-19, 1985. 18 p. refs
(SAE PAPER 850853)

Recently, recommendations were furnished to the FAA by the General Aviation Safety Panel (GASP) to encourage the establishment of FAA crash tolerance requirements for new seats for general aviation aircraft carrying less than 10 passengers. The guidelines were based on NASA, FAA and GASP crash test data and mil-spec standards for aircrashworthiness, particularly for the UH-60A helicopter. Analyses were performed of probable causes of accidents, impact velocities and correlations among various types of small aircraft. Impact pulse shapes and durations and survivable limits were quantified. Criteria were defined for the causes of injuries to certain parts of the body to devise standardized testing of new seat designs to determine if the seats offer adequate restraint/protection for passengers. M.S.K.

**A86-14458#**
**STUDIES OF ROTOR-AIRFRAME INTERACTIONS IN FORWARD FLIGHT**
N. M. KOMERATH, H. M. MCMAHON, and J. E. HUBBARTT (Georgia Institute of Technology, Atlanta) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 10 p. refs
(Contract DAAG29-82-K-0094)
(AIAA PAPER 85-5015)

The helicopter rotor and airframe cannot be treated in isolation if significant improvements in forward-flight performance are to be achieved; rotor-airframe interaction effects must be understood and predictable. Results from an experimental/analytical study of this interaction problem are presented and discussed. The experimental results include mean and periodic pressures on the surface of a cylindrical airframe and measured mean velocity components in the rotor wake. An existing prediction code is used to calculate mean pressures and velocity components which are compared with the experimental results. The impingement of the rotor wake on the airframe causes significant effects with regard to both the mean and periodic pressures. These mean effects are not adequately predicted by an available fully-coupled interaction code in its present form. A comprehensive prediction code must include unsteady effects. Author

**A86-14498#**
**THE FUNDAMENTALS OF AIRCRAFT COMBAT SURVIVABILITY ANALYSIS AND DESIGN**
R. E. BALL (U.S. Naval Postgraduate School, Monterey, CA) New York, AIAA, 1985, 410 p. refs

A comprehensive treatment is presented of military aircraft design problems to which the continuing development of antiaircraft weapons gives rise. The discussion encompasses both fixed wing and rotary wing aircraft; all mission types and combat scenarios are treated, under a general organization which distinguishes among vulnerability (due to the position of critical components), susceptibility (likelihood of detection and destruction in a given enemy threat environment), and survivability (active measures taken to ensure minimum detection and destruction probability, including battle damage repair). An attempt is made to anticipate likely developments in enemy sensor technologies and weapon lethality in the near future, as well as to project potentially fruitful aircraft design optimization solutions. O.C.

**A86-14527*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**REVIEW OF RECENT RESEARCH ON INTERIOR NOISE OF PROPELLER AIRCRAFT**
J. S. MIXSON and C. A. POWELL (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 931-949. Previously cited in issue 01, p. 4, Accession no. A85-10885. refs

**A86-14536#**
**FLUTTER AND DIVERGENCE AEROELASTIC CHARACTERISTICS FOR COMPOSITE FORWARD SWEPT CANTILEVERED WING**
I. LOTTATI (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 1001-1007. refs

An analytical investigation was conducted to determine the aeroelastic flutter and divergence behavior of a cantilevered, composite, forward swept rectangular wing. The influence due to the variation in the bending-torsion stiffness coupling of the tailored wing on the flutter and divergence critical dynamic pressure is analyzed. The analytical approach utilizes the incompressible two-dimensional unsteady aerodynamic strip theory. Flutter and divergence velocities were obtained by using an optimization procedure that solves exactly the coupled bending-torsion equations for a cantilevered swept wing. The results indicate that

the flutter and divergent of a fixed-root wing involve a compromise, since the bending-torsion stiffness that maximizes the flutter velocity tends to minimize the divergent speed and vice versa.
Author

**A86-14822**

### THE LAMINAR AIRLINER - PROSPECTS AND PROBLEMS

B. R. A. BURNS (British Aerospace, PLC, Preston, England) Air International (ISSN 0306-5634), vol. 29, Nov. 1985, p. 235-239.

A development history and performance improvement evaluation is presented for various active boundary layer control (BLC) laminarization methods that have been applied to modified and experimental aircraft in order to improve their aerodynamic efficiency and reduce their fuel consumption. Boundary layer suction through slots or holes has been the object of primary interest amon BLC techniques, often in conjunction with exotic airfoil profiles and propulsion system integration configurations. The substantial gains predicted for BLC aircraft on theoretical grounds have often, however, gone unrealized because of the inherent, boundary turbulence-generating presence of aircraft surface imperfections and vibrations, rain and ice impacts on the leading edge, and even the effect of insects that are encountered as swarms at low altitudes. O.C.

**A86-14975**

### WING ASPECT RATIO OPTIMIZATION RELATED TO PAYLOAD AND TO FUEL CONSUMPTION OF TRANSPORT PROPELLER AIRPLANES

P. A. GILI and F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy) Society of Allied Weight Engineers, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 17 p. refs
(SAWE PAPER 1615)

Solutions are obtained relating the range, payload, and fuel consumption of a propeller aircraft as a function of the wing aspect ratio (WAR) and the flight attitude (FA). A simple and reliable formula for predicting the wing weight is proposed and introduced in the flight performance (FP) equations, which express the FP as a function of the WAR only, permitting brief analysis of many design solutions in a large operational field. The analytical results allow drawing of many diagrams for the relations between the payload or fuel consumption and the FA, for optimum values of WAR at different operational ranges. I.S.

**A86-15598**

### 4 X S = S(ATF)

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Nov. 1985, p. 10-17.

A technology integration and performance forecast is presented for the U.S. Air Force's next-generation Advanced Tactical Fighter (ATF), which will become operational at the turn of the century. The most critical performance improvements envisaged for the ATF are sustained supersonic flight, short field takeoff and landing capabilities, enhanced survivability through the incorporation of stealth features (reducing IR emissions and radar cross section), and enhanced supportability in a combat scenario. Significant acceleration, maneuvering, and thrust reversal (for short landing run) contributions must be made by a 9:1 thrust/weight ratio powerplant that integrally incorporates a thrust vectoring/reversing two-dimensional variable geometry nozzle. O.C.

**A86-15999**

### DOUGLAS PLANS CONTINUING UPGRADES TO MAINTAIN MD-80 COMPETITIVENESS

K. F. MORDOFF Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Nov. 11, 1985, p. 52, 57, 59, 61, 65.

A projection is made of configurational possibilities and prospective performance improvements obtainable for the MD-80 family of medium size airliners. The two primary variants foreseen are the MD-87, for the 115-130 seat transport class, which will be derived by a shortening of the MD-80 fuselage, and the 160-seat MD-89, derived by stretching the MD-80. In the longer term, attention is to be given to the incorporation of ultrahigh bypass engines which may be of either propfan or unducted fan type. More extensive primary structural use is planned for carbon/epoxy and kevlar/epoxy composites, and novel carbon or glass fiber-reinforced phenolics will be introduced. O.C.

**A86-16000**

### AIRBUS INDUSTRIE STRESSES TECHNOLOGY, AVAILABILITY OF A320

J. M. LENOROVITZ Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Nov. 11, 1985, p. 81, 83, 85.

A performance capability and market viability assessment is made for the state-of-the-art technology A320 airliner, whose total orders and options over the course of 1986 are expected to rise to nearly 300 aircraft. Certification for the A320 is scheduled for 1988, using CFM56-5 engines. The airliner will seat 120-179 passengers, depending on cabin configuration, and it incorporates fly-by-wire controls, pilot/copilot sidestick controllers, a centralized maintenance data system, a novel wing design with automatic load alleviation, and extensive use of composite materials in both primary and secondary structures. The manufacturer has begun to survey prospective customers for the requirements of twin-engine (TA-9) and four-engine (TA-11) wide body airliners. O.C.

**A86-16095**

### THE V-22 - PREPARING FOR FULL-SCALE DEVELOPMENT

R. J. TRACY (U.S. Naval Air Systems Command, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 31, Nov.-Dec. 1985, p. 27-29.

The V-22 tilt-rotor aircraft must possess a range of over 2000 mi, have rotors under 38 ft diam, and in shipboard basing weigh less than 25 tons. The V-22 is approaching full-scale development after 6000 hr of wind tunnel tests to characterize the configuration, drag, rotor effects, spin behavior, aeroelstic boundaries, the engine nacelle airflow characteristics and methods validation. Longitudinal instability at a low lift coefficient has been eliminated and the scale model results indicate a flutter-free performance at over 420 kt. Some of the design choices, such as the nacelle tilt in hover, have been validated on the XV-15 aircraft. Full-size tests have been performed on the wing structure, which will sport 1200 lb of composite parts. Particular attention is being given to minimizing weight as the design studies progress. M.S.K.

**A86-16097**

### TOMORROW'S FLEET - THE LIGHT HELICTOPER FAMILY (LHX)

R. K. ANDERSON (U.S. Army, Aviation Systems Command, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 31, Nov.-Dec. 1985, p. 42-46.

The development program for the next generation of light rotorcraft has progressed to contracts for the turboshaft engine and the preparation of the RFP for the LHX air vehicle system. The LHX will have two variants: the scout/attack aircraft (SCAT) and light utility (U). Both will be capable of one-person operation, flight in adverse weather and achieve 40-50 percent cost redutions compared to the current fleet. The avionics will be state of the art digital equipment, driven by VHSIC and accepting voice commands. The total procurement will be 5023 aircraft. The program is in the concept exploration stage, and has defined the gross weight interval as 7500-8500 lb and at $6/4 million each for the SCAT/U vehicles. Innovation has been the guideword in defining the LHX specifications, which will only be 40 pages long.
M.S.K.

**A86-16123**

### FEASIBILITY OF SIMPLIFYING COUPLED LAG-FLAP-TORSIONAL MODELS FOR ROTOR BLADE STABILITY IN FORWARD FLIGHT

G. R. NILAKANTAN (Hindustan Aeronautics, Ltd., Bangalore, India) and G. H. GAONKAR (Florida Atlantic University, Boca Raton) (European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 3, 1985, p. 241-256. refs

The feasibility of simplifying coupled lag-flap-torsional models is explored for the low-frequency stability of isolated hingeless rotor blades in forward flight. The nonlinear equations of moderate deflections with appropriate geometric nonlinearities are valid to third order, so are the perturbed linear equations about time dependent equilibrium (trim) positions. Aerodynamic strip theory based on a quasisteady approximation of two-dimensional unsteady airfoil theory is used. Under linear and quasilinear propulsive trim conditions, stability is investigated for four cases: a base-line model with elastic lag bending, flap bending and torsion degrees of freedom, the modified elastic lag-flap model that neglects only torsional dynamic effects, and the rigid blade models with and without quasisteady approximation to torsion. The method of equivalent Lock number and drag coefficient is used for qualitative insights into dynamic inflow effects. The range of validity of the modified elastic lag-flap and rigid lag-flap models is outlined with respect to torsional frequencies for soft (including matched stiffness) and stiff inplane rotors. Author

**A86-16124**

**THE EFFECT OF HIGHER HARMONIC CONTROL (HHC) ON A FOUR-BLADED HINGELESS MODEL ROTOR**

G. LEHMANN (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) (European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 3, 1985, p. 273-284. refs

A four-bladed hingeless rotor system was used for application of higher harmonic control (HHC) inputs. With the objective of obtaining a better knowledge of the dynamic behavior of rotor forces and moments theoretical and experimental investigations were conducted. Wind tunnel measurements in the DNW with the DFVLR rotor test rig included different advance ratios and trimmed flight conditions scaled down from the BO-105 helicopter. After a brief description of the test equipment, the sensor arrangement, the data acquisition and data reduction, the evaluation of the reference data will be described. In the second part of this contribution the effect of the 3, 4 and 5/rev control inputs to the vibratory hub and blade loads are demonstrated. The major aspect to be discussed is the extraction of nonlinearities and couplings in the control inputs, which are the amplitudes and phases of the three higher harmonic blade pitch angles. Additionally comparisons of the cost functions, used at simulation runs and the wind tunnel tests, are described. The cost function gives a value for the vibration level on the dedicated rotor system which is an input for most of the common HHC algorithms. Author

**A86-16125**

**EXPERIENCE WITH A NEW APPROACH TO ROTOR AEROELASTICITY**

M. H. PATEL and G. T. S. DONE (City University, London, England) (European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 3, 1985, p. 285-294. Research supported by the Ministry of Defence. refs

Experience with an alternative procedure for computing the aeroelastic stability of a helicopter rotor system is described. The method has already been presented at a previous European Rotorcraft Forum, and is aimed at generating the coefficients of the aeroelastic equations of motion automatically on the computer. The main objective of the current work is to validate the associated computer program using three practical examples provided by Westland Helicopters Ltd. These examples are graded such that different aspects of the program are tested. The validation exercise is completed by comparing the results obtained by the new method with those previously obtained using conventional techniques, and providing explanation for discrepancies where they occur. Author

**N86-12217** Department of the Air Force, Washington, D.C.

**PNEUMATIC ACTUATOR DEVICE Patent**

R. W. GAZZERA, inventor (to Air Force) 16 Apr. 1985 7 p
Supersedes AD-D009822
(AD-D011794; US-PATENT-4,510,846;
US-PATENT-CLASS-91-460) Avail: US Patent and Trademark Office CSCL 13K

A closed center four-way poppet actuator control device is incorporated into a pneumatic actuation system for controlling the movement of flight surfaces. The closed center four-way poppet actuator control device has a housing, a pair of two-way poppet valves in the housing, a rocker arm assembly mounted on the housing and connected to the pair of two-way poppet valves, and a diaphragm assembly also mounted in the housing and in contact with the two-way valves. A torque motor-driver assembly connected to the diaphragm assembly actuates the two-way valves as determined by control symbols. The rocker arm causes the two-way valves to function opposite each other: one allows high pressure gas to be input to a lobe motor acutator while the other allows gas to be output from the lobe motor actuator. Each two-way valve has a cylindrical poppet valve for inletting the gas to the actuator and a disk poppet valve for outputting the gas from the actuator to a vent. The actuator causes movement of the flight surfaces through a gearbox. A velocity transducer monitors this movement and transmits this movement to an electronic control unit which sends control signals to drive the torque motor-driver assembly that actuates said actuator control device. Author (GRA)

**N86-12219#** Army War Coll., Carlisle Barracks, Pa.

**THE C-17: WE NEED IT YESTERDAY**

B. R. HOOTEN 25 Apr. 1985 37 p
(AD-A157147) Avail: NTIS HC A03/MF A01 CSCL 01C

This student essay examines the historical development of the C-17, beginning in the 1970's when Tactical Airlift Command was pressing for development of the Advanced Medium Shortfield Takeoff and Landing Transport. An in-depth look is taken at the Congressionally Mandated Mobility Study and at the analyses done by the C-X Task Force that led to the final definition of the C-17. The US Air Force Airlift Master Plan is reviewed to show the importance of the C-17 to the structure of our airlift force of the future. Real world potential applications of the C-17 are projected by examination of two studies of actual airlift operations. AHUAS TARA '83, (a combined operation in Honduras) and URGENT FURY, the US rescue mission to Grenada in October 1983. This essay supports the need to buy the C-17 by showing the detailed, logistical process that led to its design, and by using two recent actual operations to show the airplane's unprecedented airlift capabilities of today and into the foreseeable future. GRA

**N86-12450#** Joint Publications Research Service, Arlington, Va.

**WINGTIP SAILS TESTED ON Y-5 AIRCRAFT**

Y. DAXI *In its* China Rept.: Sci. and Technol. (JPRS-CST-85-029) p 49-53 3 Sep. 1985 Transl. into ENGLISH from Guoji Hangkong (Beijing), no. 5, May 1985 p 2-3
Avail: NTIS HC A08/MF A01

In recent years, much attention has been given to the use of wingtip ailerons or wing tip sails to reduce induced drag because for most transport airplanes, the induced drag at cruising speed is approximately 30 percent of the total drag; at lower speeds the ratio is even higher. For the Y-5 biplane, the induced drag to total drag ratio is approximately 55.6 percent, at cruising speed the ratio is approximately 33 percent, and during climb it is 58 percent. Therefore, wing tip ailerons or wing tip sails potentially can be very effective in reducing the overall drag of the aircraft. Since a large number of Y-5 airplanes are used in China for a variety of applications, a research program was initiated in August 1982 to install and test wing tip sails on the Y-5 aircraft. Results show that the use of wing tip sails improved the performance of the Y-5 aircraft. Author

**N86-13316*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### ABRASION BEHAVIOR OF ALUMINUM AND COMPOSITE SKIN COUPONS, STIFFENED SKINS AND STIFFENED PANELS REPRESENTATIVE OF TRANSPORT AIRPLANE STRUCTURES

K. E. JACKSON Nov. 1985 33 p refs
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TP-2520; L-16018; NAS 1.60:2520; AVSCOM-TR-85-B-7)
Avail: NTIS HC A03/MF A01 CSCL 01C

A three-phase investigation was conducted to compare the friction and wear response of aluminum and graphite-epoxy composite materials when subjected to loading conditions similar to those experienced by the skin panels on the underside of a transport airplane during an emergency belly landing on a runway surface. The first phase involved a laboratory test which used a standard belt sander to provide the sliding abrasive surface. Small skin-coupon test specimens were abraded over a range of pressures and velocities to determine the effects of these variables on the coefficient of friction and wear rate. The second phase involved abrading I-beam stiffened skins on actual runway surface over the same range of pressures and velocities used in the first phase. In the third phase, large stiffened panels which most closely resembled transport fuelage skin construction were abraded on a runway surface. This report presents results from each phase of the investigation and shows comparisons between the friction and wear behavior of the aluminum and graphite-epoxy composite materials. Author

**N86-13317*#** Operations Research, Inc., Rockville, Md.

### TRADEOFF ANALYSIS OF TECHNOLOGY NEEDS FOR PUBLIC SERVICE HELICOPTERS

J. S. BAUCHSPIES, W. R. BRYANT, JR., and W. E. SIMPSON Aug. 1985 120 p refs
(Contract NASW-3554)
(NASA-CR-3927; NAS 1.26:3927; ORI-TR-2459) Avail: NTIS HC A06/MF A01 CSCL 01C

The design requirements for a family or type of Public Service Helicopter (PSH) is examined which will satisfy the needs of municipal and state governments in the following mission areas: Emergency Medical Service--Airborne Rescue Squad; Law Enforcement; Search and Rescue; and Environmental Control (Fire Fighting, Pollution, Resource Management). The report compares both design and performance requirements as specified by the PSH user's group against current technological capabilities, RTOPS and US Army LHX design requirements. The study explores various design trade-offs and options available to the aircraft designer/manufacturer in order to meet the several criteria specified by the PSH user's group. In addition, the report includes a brief assessment of the feasibility of employing certain advanced rotorcraft designs to meet the stringent combination of operational capabilities desired by the Public Service Helicopter Users. Author

**N86-13318*#** National Aeronautics and Space Administration, Washington, D.C.

### AIRCRAFT OF THE FUTURE

S. YEGER (OKB Tupolev, USSR) Nov. 1985 9 p Transl. into ENGLISH from Techn.-Oekonomische Inform. der Zivilen Luftfahrt (West Germany), v. 13, no. 2, 1977 p 88-90 Original language document was announced in IAA as A77-39452 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77952; NAS 1.15:77952) Avail: NTIS HC A02/MF A01 CSCL 01C

Some basic problems connected with attempts to increase the size and capacity of transport aircraft are discussed. According to the square-cubic law, the increase in structural weight is proportional to the third power of the increase in the linear dimensions of the aircraft when geomettric similarity is maintained, while the surface area of the aircraft increases according to the second power. A consequence is that the fraction of useful weight will decrease as aircraft increase in size. However, in flying-wing designs in which the whole load on the wing is proportional to the distribution of lifting forces, the total bending moment on the wing will be sharply reduced, enabling lighter construction. Flying wings may have an ultimate capacity of 3000 passengers. DOE

**N86-13319*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### PRELIMINARY REPORT ON IN-FLIGHT MEASUREMENT OF ROTOR HUB DRAG AND LIFT USING THE RSRA

C. W. ACREE, JR. Oct. 1985 28 p refs
(NASA-TM-86764; REPT-85288; NAS 1.15:86764) Avail: NTIS HC A03/MF A01 CSCL 01C

The Rotor Systems Research Aircraft (RSRA) is a compound helicopter that was test flown as a fixed wing aircraft, with the main rotor blades removed and the rotor hub installed. An onboard rotor load measurement system measured the resulting rotor hub drag and lift. Measured hub drag and lift are plotted for comparison to that predicted by full scale and 1/6 scale model wind tunnel tests. The success of the demonstration gives confidence that planned improvements to the RSRA will allow high accuracy hub drag and lift measurements to be made in flight on a routine research basis. Author

**N86-13320*#** Texas Technological Univ., Lubbock. Dept. of Electrical Engineering/Computer Science.

### INTERPRETATION OF F-106B IN-FLIGHT LIGHTNING SIGNATURES

T. F. TROST, M. G. GROTHAUS, and C. T. WEN Aug. 1985 51 p refs
(Contract NAG1-28)
(NASA-CR-176387; NAS 1.26:176387) Avail: NTIS HC A04/MF A01 CSCL 01C

Various characteristics of the electromagnetic data obtained on a NASA F-106B aircraft during direct lightning strikes are presented. Time scales of interest range from 10 ns to 400 microsecond. The following topics are discussed: (1) Lightning current, I, measured directly versus I obtained from computer integration of measured I-dot; (2) A method of compensation for the low frequency cutoff of the current transformer used to measure I; (3) Properties of fast pulses observed in the lightning time-derivative waveforms; (4) The characteristic D-dot signature of the F-106B aircraft; (5) An RC-discharge interpretation for some lightning waveforms; (6) A method for inferring the locations of lightning channel attachment points on the aircraft by using B-dot data; (7) Simple, approximate relationships between D-dot and I-dot and between B and I; and (8) Estimates of energy, charge, voltage, and resistance for a particular lightning event. Author

**N86-13321*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### GROUND VIBRATION TEST OF THE LAMINAR FLOW CONTROL JSTAR AIRPLANE

M. W. KEHOE (NASA. Ames Research Center), F. W. CAZIER, JR. (NASA. Ames Research Center), and J. F. ELLISON Oct. 1985 61 p
(NASA-TM-86398; L-15949; NAS 1.15:86398) Avail: NTIS HC A04/MF A01 CSCL 01C

A ground vibration test was conducted on a Lockheed JetStar airplane that had been modified for the purpose of conducting laminar flow control experiments. The test was performed prior to initial flight flutter tests. Both sine-dwell and single-point-random excitation methods were used. The data presented include frequency response functions and a comparison of mode frequencies and mode shapes from both methods. Author

**N86-13322#** Royal Aircraft Establishment, Farnborough (England).
**STANDARDISED FATIGUE LOADING SEQUENCES FOR HELICOPTER ROTORS (HELIX AND FELIX). PART 2: FINAL DEFINITION OF HELIX AND FELIX**
P. R. EDWARDS and J. DARTS Aug. 1984 124 p
(AD-A156622; RAE-TR-84085; DRIC-BR-95846) Avail: NTIS HC A06/MF A01 CSCL 14B

This report defines two loading standards for the fatigue evaluation of helicopter rotor materials and components. They were developed as a collaborative study between West Germany, the Netherlands and UK. Details of the contributing organizations are given in Appendix A. The new loading standards follow the earlier TWIST (Transport Wing Standard), and FALSTAFF (Fighter Aircraft Loading Standard For Fatigue evaluation). After the tradition of these earlier loading sequences, the new loading standards have been given identifying names. For these the origin of the word helicopter (Helix-spiral, pteronwing from the Greek) has provided a convenient basis. The new standards are called: Helix loading standard for hinged or articulated rotors; Felix loading standard for fixed or semi-rigid rotors. This report defines the final form of the two standards, statistical content according to different counting methods and full details of their method of generation. GRA

**N86-13323#** Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
**LIMITED AIRWORTHINESS AND FLIGHT CHARACTERISTICS (A AND FC) TEST OF THE QUICK FIX CONFIGURATION Final Report, 23 May - 27 Jun. 1984**
G. L. SKINNER, G. M. BISHOP, E. J. TAVARES, and R. C. MURRELL Oct. 1984 67 p
(AD-A157716; USAAEFA-83-20) Avail: NTIS HC A04/MF A01 CSCL 01C

The US Army Aviation Engineering Flight Activity conducted an evaluation to determine the increase in power required and the change in handling qualities due to the installation of the AN/ALQ-151(V)2 countermeasures system and associated mission equipment on the UH-60A helicopter. Testing conducted between 23 May to 2 June 1984 totaled 12.4 hours. The addition of the Quick Fix System and associated mission equipment created an increase in equivalent flat plate area (F sub e) of 17 sq ft (ft2) for advance ratios (mu) of 0.26 and greater. For mu's less than 0.26, the change in F sub e increased above 17 sq ft as a function of thrust coefficient. Handling qualities of the Quick Fix configured YEH-60A were unchanged from a normal utility configured UH-60A and were determined satisfactory. One deficiency, interference between the main rotor blades and the upper elements of the (no. 3 and no. 4) direction finding dipole antennas during ground taxi and four shortcomings were associated with the Quick Fix configuration. GRA

**N86-13324#** SRI International Corp., Menlo Park, Calif.
**PHYSICAL DISTRIBUTION SYSTEM FOR AIRCRAFT EXTERNAL FUEL TANKS-SURVEY Final Report, 1 Mar. - 31 May 1985**
G. B. ANDEEN, R. D. KORNBLUH, T. P. LOW, R. H. MONAHAN, and W. PARK Jun. 1985 96 p
(Contract N00600-82-D-8362)
(AD-A158275; DTNSRDC/CMLD-CR-47-85) Avail: NTIS HC A05/MF A01 CSCL 13D

The general objective of this study was to conduct a survey and analysis of current and planned aircraft external fuel tanks, with emphasis on the disposability and nestability aspects of these fuel tanks. The study focused on design requirements, fabrication and assembly, and physical distribution, with particular attention directed to the use of the robotic equipment for the assembly of nestable fuel tanks aboard the ship. The principal conclusion of this study is that the development of disposable, nestable external aircraft fuel tanks with automated assembly aboard ship, using robotic equipment, is a feasible option for implementation within the next five to ten years. Chapter 1 of the report presents an introduction and summary description of the major results of the survey. Chapter 2 then provides a summary description of the tentative operational requirements established by the Navy for disposable, nestable external aircraft fuel tanks. Chapter 3 presents a discussion of the possible fabrication and assembly techniques and problems for such fuel tanks. Chapter 4 then discusses the physical distribution aspects of external aircraft fuel tanks. Chapter 5 concludes with a listing of the conclusions and recommendations resulting from this analysis. GRA

**N86-13325#** Hughes Helicopters, Culver City, Calif.
**ADVANCED TECHNOLOGY HELICOPTER LANDING GEAR PRELIMINARY DESIGN INVESTIGATION Final Report, Sep. 1983 - Jul. 1984**
J. K. SEN, M. W. VOTAW, and D. C. WEBER Jul. 1985 247 p
(Contract DAAK51-83-C-0039; DA PROJ. 1L1-62209-AH-76)
(AD-A158816; HHI-84-284; USAAVSCOM-TR-84-D-20) Avail: NTIS HC A11/MF A01 CSCL 01C

This report describes the preliminary designs of two configurations of helicopter crashworthy landing gears: (1) with the trailing arms of the main gear coupled with a torque, which forces both shock struts to absorb the kinetic energy of an unsymmetrical crash impact, and (2) with the trailing arms uncoupled; i.e., the torque tube is replaced by a cross tube which is incapable of reacting the high torsional load of an unsymmetrical crash impact. Retractable and fixed landing gears of both configurations have been designed, as well as a standard (noncrashworthy) retractable landing gear. All landing gears are of tailwheel designs. The designs apply the systems approach to crashworthiness where the total impact energy absorbed is shared by the landing gear, fuselage and seat. The designs of the crashworthy landing gears were completed after a preliminary investigation of crash impact at sink speeds up to 42 fps, roll angles up to + or - 20 degrees and pitch angles up to -10+20 degrees. The crashworthy evaluations were made with program KRASH. A detailed analysis with KRASH was then conducted for all configurations of landing gears. Based on the weight trend curves and cost analysis, a crashworthy design criterion was recommended. This design criterion was the basis for updating the landing gear design. The designs identify the fabrication methods and processes for the landing gear. Estimates of cost and weight of the updated designs are also presented. GRA

**N86-13326#** Sikorsky Aircraft, Stratford, Conn.
**TRANSMISSION ACOUSTIC VIBRATION TESTING Final Report, Sep. 1982 - Nov. 1983**
C. YOERKIE and A. CHORY Jul. 1985 85 p
(Contract DAAK51-82-C-0040; DA PROJ. 1L2-63201-DB-72)
(AD-A159022; USAAVRADCOM-TR-83-D-34) Avail: NTIS HC A05/MF A01 CSCL 01C

Laboratory tests were conducted to determine the individual and combined effects of a high contact ratio (HCR) planetary gearset and a stainless steel housing on the acoustic (high frequency) vibration signature of the BLACK HAWK helicopter main transmission. Vibration levels at the planetary mesh frequency increased significantly with the stainless steel housing, but increased unexpectedly with the HCR planetary. The primary reason for the increased response with the HCR was the reduced gear face widths. GRA

**N86-13327#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**AIRCREW DOSE AND ENGINE DUST INGESTION FROM NUCLEAR CLOUD PENETRATION M.S. Thesis**
S. P. CONNERS Mar. 1985 168 p
(AD-A159246; AFIT/GNE/PH/85M-4) Avail: NTIS HC A08/MF A01 CSCL 01B

This thesis evaluates the threat to aircraft and aircrew from dust and radioactivity in a cloud generated by nuclear surface bursts. A model of the nuclear cloud is generated, using any number and type of weapons and any desire dust size distribution. The cloud is propagated through the atmosphere for a given time, then penetrated by an aircraft. The activity density in the cloud is converted to dose to the crew for a given path through the cloud. Radiation shielding and dust filters are included in the calculations. Alternatively, the cloud dust mass density can be converted to mass trapped in a filter or the cabin, or to the dust mass that has entered the engine. Methods for determining particle size and altitude distributions are presented. The ionizing dose to the crewmember is computed for both sky-shine and the dust trapped in the cabin during cloud passage. A method of computing the shielding power of the crew compartment against sky-shine is presented. Given the air flow rate into a filter or engine, the mass of ingested dust is found. These nuclear cloud and aircraft models are incorporated in a computer code oriented toward operational use. A significant feature of the code includes the ability to easily change the scenario with menu driven options. GRA

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-12683**

**MISSILE GUIDANCE BASED ON KALMAN FILTER ESTIMATION OF TARGET MANEUVER**

Y. M. TANG (Chinese Aeronautical Establishment, Luoyang Dynamic Institute, People's Republic of China) and J. A. BORRIE (Cranfield Institute of Technology, England) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-20, Nov. 1984, p. 736-741. refs

A weakness of conventional proportional navigation for a homing missile is related to a limited effectiveness in coping with evasive maneuvers of the target. The present investigation is concerned with an extended Kalman filter which generates an estimate of target lateral acceleration. This estimate is used together with other information to generate the required lateral missile acceleration, taking into account a precomputed suboptimal control law. Attention is given to a simplified model of target behavior, the design of the extended Kalman filter, system model and missile guidance law design, and a computer simulation. The simulation shows that a substantial improvement in miss distance is achieved. G.R.

**A86-13202**

**AIR FORCE FLIGHT TEST INSTRUMENTATION SYSTEM**

M. F. LAMY (SCI Systems, Inc., Huntsville, AL) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 13-19.

The U.S. Air Force's Flight Test Instrumentation System (AFFTIS) is being developed to furnish flight test instrumentation capabilities for aircraft through the 1990s. The AFFTIS System Controller (ASC) orchestrates the functions of the airborne PCM system, which encompasses a central control unit and distributed data acquisition units (DAUs) via high speed serial/response data bus. Each of the remote DAUs includes a memory containing format information. The command from the ASC points to the correct format instruction location within the DAU. All of the PCM format structure is user-definable and programmable. Attention is given to ground and laboratory support equipment. O.C.

**A86-13215**

**A PROGRAMMABLE DATA ACQUISITION SYSTEM WITH INTEGRATED TEST AND CALIBRATION FACILITIES**

A. ZACH and R. GANDERT (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 155-172.

The accurate and testable data acquisition system developed for the Advanced Technologies Testing Aircraft System consists of a distributed modular microprocessor system with signal conditioning units that are located near the system's sensors. Control is exercised by a master unit with integral PCM encoder. Flexible signal conditioning, which features software-controlled parameters and adaptable signal inputs, can be automatically tested via an analog calibration bus that uses switchable signal paths. O.C.

**A86-13269**

**MILITARY AVIONICS**

G. WARWICK Flight International (ISSN 0015-3710), vol. 128, Oct. 5, 1985, p. 24-31.

The advanced cockpit displays being developed to exploit the capabilities of state of the art digital avionics are described, along with the avionics systems. Triple and quadruple redundancy is being used to enhance digital systems, and their associated servosystems, to reliability levels offered by part-mechanical systems. The introduction of color-coded CRT graphics displays, voice activated controls and AI into the cockpit alters the pilot role to that of a flight manager. Recent advances in shadow-mask CRT technologies have provided the full-color, adequate brightness/resolution and reliability, i.e., vibration resistance, needed for fighter cockpit applications such as moving map displays. For the on-board computer, multiple pathways augment failure tolerance and allow majority voting, although triply redundant systems must employ more self-checking than quadruply redundant systems. Acceptable totally fly-by-wire systems permit active, automated control of dynamically unstable aircraft configurations such as the X-29. M.S.K.

**A86-13548**

**ALTIMETERS TO MEET MILITARY LOW LEVEL NEEDS**

B. WANSTALL Interavia (ISSN 0020-5168), vol. 40, Oct. 1985, p. 1127, 1128.

Military requirements for greater trajectory accuracy at low altitudes, and lighter and more compact equipment, are being addressed by a new generation of CW and pulsed radio altimeter equipment technologies. Attention is presently given to the Spectrum Leading Edge Detection technique, which overcomes limitations associated with conventional FM/CW systems, a German FM/CW radio altimeter for military helicopters which incorporates two antennas and weighs 1 kg, and pulsed J-band radio altimeters that are smaller, lighter and cheaper than the conventional devices. O.C.

**A86-14220**

**ICING WIND TUNNEL TESTS ON THE CSIRO LIQUID WATER PROBE**

W. D. KING (CSIRO, Cloud Physics Laboratory, Sydney, Australia), J. E. DYE, J. W. STRAPP (National Center for Atmospheric Research, Boulder, CO), D. BAUMGARDNER (Department of the Environment, Atmospheric Environment Service, Downsview, Canada), and D. HUFFMAN (Particle Measuring Systems, Inc., Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 2, Sept. 1985, p. 340-352. refs

The CSIRO probe for airborne measurements of liquid water content (LWC) is currently used by many research organizations. It was felt that a series of icing wind tunnel comparisons and calibrations of the type performed on the Johnson-Williams (JW) probe by Strapp and Schemenauer (1982) would help to evaluate the performance of the probe. The present paper provides a description of such tests. Aspects of tunnel calibration awe discussed along with the tunnel profiles, details regarding the employed probes, and the analysis of the probe data. Attention is given to the effect of varying yaw angle, the effects of varying the operating temperature, the effect of airspeed, the effect of ambient temperature, the replacement heads, the effects of power supply voltage, the offset voltage and its effect on damping, long-term stability, inoperative slave wires and inconsistencies. G.R.

**A86-14223**
**EVALUATION OF METEOROLOGICAL AIRBORNE DOPPLER RADAR. I DUAL-DOPPLER ANALYSES OF AIR MOTIONS. II - TRIPLE-DOPPLER ANALYSES OF AIR MOTIONS**
P. H. HILDEBRAND and C. K. MUELLER (National Center for Atmospheric Research, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 2, Sept. 1985, p. 362-392. refs

A number of studies have shown that ground-based Doppler radars are valuable tools for atmospheric sciences research. However, ground-based Doppler observations are limited to measurements of phenomena which occur within the area covered by the radars. Some of the problems of ground-based radars can be overcome by making use of airborne Doppler radars. During the past two years, the potential value of practical airborne Doppler radar systems has been demonstrated in tests of a 3-cm Doppler radar aboard the NOAA P3 aircraft. In the present paper, observations are presented of a convective storm by airborne and ground-based Doppler radars, taking into account also the subsequent comparative analyses of the storm structure. G.R.

**A86-14433#**
**AUTOMATION AND INTEGRATION ON AFTI/F-16**
A. F. BARFIELD and F. R. SWORTZEL (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 8 p.
(AIAA PAPER 85-3089)

The techniques being pursued in the Advanced Fighter Technology Integration (AFTI/F-16) program to provide enhanced automation, effectiveness and reliability in fighter aircraft are surveyed. The goal is to furnish increased lethality and deliverability of weapons systems and augmented maneuverability while keeping the pilot workload at manageable levels. Triply-redundant computers provide for fully digital mechanization for multimode flight control. Each flight phase is decoupled from others and automated wherever possible, in addition to simplifed vertical and sideways manual translation control. Enhanced control is achieved with blended surfaces control, with control modes selected as one-button options. Automation also covers trajectory control for bombing, air-to-air gunnery, collision avoidance and integrated systems operation. M.S.K.

**A86-15314**
**RADIOMETRIC CHARACTERIZATION METHODS FOR INFRARED COUNTERMEASURES SYSTEMS**
J. L. GRANGAARD (USAF, Infrared and Laser Standards Laboratory, Newark Air Force Station, OH), C. LINK (Northrop Corp., Defense Systems Div., Rolling Meadows, IL), G. SPADE (Sanders Associates, Inc., Nashua, NH), and W. RAMSEY (Loral Electro-Optical Systems, Inc., Pasadena, CA) IN: Optical radiation measurements; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 39-46.

For the purpose of jamming an infrared tracker, Infrared Countermeasures Systems (IRCM) produce a complicated pulsed pattern of infrared radiation. The produced radiation varies rapidly with time, direction, and wavelength. Large simulation facilities are employed to test the effect which these systems produce on the tracking ability of an infrared seeker. A number of measurement facilities have been designed for the evaluation of IRCM systems. The present paper provides a detailed description of the measurement system used at Newark Air Force Station. Attention is given to the radiometer measurement equation, the relative spectral output measurement, spectral scaling factor measurement, an estimate of measurement error, methods of measuring radiant intensity, and an intercomparison of techniques. G.R.

**A86-15342**
**FIBER OPTIC AIRCRAFT SYSTEMS ELECTROMAGNETIC PULSE (EMP) SURVIVABILITY**
B. GAGE, R. GREENWELL, M. SUMMERLIN, and B. ZETLEN (Science and Engineering Associates, Inc., Seattle, WA) IN: Fiber optics in adverse environments II; Proceedings of the Meeting, San Diego, CA, August 22-24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 109-115. refs

It is pointed out that a single eletromagnetic pulse (EMP) event can disrupt or destroy vital military electronics and aircraft avionics which operate in an area as large as the entire continental United States. This paper is concerned with the application of fiber optic technology for aircraft systems EMP survivability optic technology. In the case of the present methodology of data and signal transfer in aircraft, complex electromagnetic protection techniques are needed to protect aircraft avionics from lightning, EMP, and electromagnetic interference. The EMP problem is further enhanced by the increased use of new nonmetallic composite aircraft structural materials which diminish outer layer topological shielding. Fiber optic technology, in connection with its inherent dielectric nature, provides the most cost-effective alternative to conventional shielded transmission paths. G.R.

**A86-15378**
**INFRARED FLIGHT SIMULATION USING COMPUTER GENERATED IMAGERY**
M. R. WEATHERSBY and W. M. FINLAY (Georgia Institute of Technology, Atlanta) IN: Infrared technology X; Proceedings of the Meeting, San Diego, CA, August 23, 24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 89-93. Army-sponsored research. refs

A deterministic, interactive software model has been developed for the computer generation of three-dimensionally projected IR scenes, on the basis of either self-emission or near-IR reflectance, and allowing for generation of flight paths through a data base that consists of both feature and topography. The three-dimensional IR background clutter model furnishes an evaluation tool for the assessment of system performance in clutter, and for deepening current understanding of the clutter phenomenon itself. Applications include sensor operator training with dynamic imagery, and the evaluation of automatic target recognition algorithms. O.C.

**A86-15599**
**LANTIRN - TURNING NIGHT INTO DAY**
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Nov. 1985, p. 18-22.

The low altitude navigational targeting IR night (LANTIRN) system is an autonomous, pod-mounted fire-control system for tactical aircraft that is linked to a cockpit HUD, facilitating nocturnal missions in adverse weather conditions against low latitude targets. LANTIRN will be installed on 392 F-15E, 200 F-16, and 100 A-10 aircraft. Attention is presently given to the subcomponent configuration of the system and its functions on typical bombing runs. O.C.

**N86-12220*#** Dayton Univ., Ohio.
**PERFORMANCE OF AN ALPHA-VANE AND PITOT TUBE IN SIMULATED HEAVY RAIN ENVIRONMENT Final Report**
J. K. LUERS and I. B. FISCUS Oct. 1985 32 p refs
(Contract NAG1-522)
(NASA-CR-176353; NAS 1.26:176353; UDR-TR-85-131) Avail: NTIS HC A03/MF A01 CSCL 01D

Experimental tests were conducted in the UDRI Environmental Wind/Rain Tunnel to establish the performance of an alpha-vane, that measures angle of attack, in a simulated heavy rain environment. The tests consisted of emersing the alpha-vane in an airstream with a concurrent water spray penetrating vertically through the airstream. The direction of the spray was varied to make an angle of 5.8 to 18 deg with the airstream direction in order to simulate the conditions that occur when an aircraft lands in a heavy rain environment. Rainrates simulated varied from 1000 to 1200 mm/hr which are the most severe ever expected to be encountered by an aircraft over even a 30 second period. Tunnel airspeeds ranged from 85 to 125 miles per hour. The results showed that even the most severe rainrates produced a misalignment in the alpha-vane of only 1 deg away from the airstream direction. Thus for normal rain conditions experienced by landing aircraft no significant deterioration in alpha-vane performance is expected. B.W.

**N86-12221#** Air Force Flight Test Center, Edwards AFB, Calif.
**T-33 (SILVER STAR MK 3) PITOT-STATIC SYSTEM CALIBRATION Final Report, 17 Apr. - 15 May 1985**
T. R. WOODFORD and E. P. HANSEN Jun. 1985 34 p
(AD-A157854; AFFTC-TR-85-19) Avail: NTIS HC A03/MF A01 CSCL 01D

This report presents the results of pitot-static system calibration tests performed on T-33 (Silver Star MK 3), civil registration number N83TB. The T-33 pitot-static system was calibrated in order to use the T-33 as a pacer for the T-46A pitot-static system calibration tests to be performed during the T-46A Development Test and Evaluation Program. Although the test aircraft will perform satisfactorily as a pacer, periodic checks on the pitot-static system's accuracy should be performed. GRA

**N86-12222#** Sanders Associates, Inc., Nashua, N. H.
**ADVANCED AVIONICS COMPUTER ARCHITECTURE. VOLUME 1. EXECUTIVE SUMMARY Final Report, May 1980 - Nov. 1984**
L. GREENSPAN and R. SINGLETARY May 1985 19 p
(Contract F33615-79-C-1935)
(AD-A158119; AFWAL-TR-85-1041-VOL-1) Avail: NTIS HC A02/MF A01 CSCL 09B

This exploratory development program was originally aimed at developing a computer with features to specifically support the JOVIAL (J73) programming language with considerations to Ada. Later, the program was redirected to modify the instruction set architecture (ISA) to more fully support Ada and increase performance. The new ISA supports most of the standard functions found in most ISA, but gives additional supports in: the Ada package concept, processing arrays and records, unconstrained arrays, dynamic storage allocation, detecting dangling references, detecting undefined variables, Ada-like exception handling, case instructions, for-loop instructions, Ada-like parameter passing, Ada-like tasking instructions and IEEE-standard floating point data types. GRA

**N86-12223#** Sanders Associates, Inc., Nashua, N. H.
**ADVANCED AVIONICS COMPUTER ARCHITECTURE. VOLUME 2. INSTRUCTION SET ARCHITECTURE SPECIFICATION Final Report, May 1980 - Nov. 1984**
L. GREENSPAN and R. SINGLETARY May 1985 305 p 2 Vol.
(Contract F33615-79-C-1935)
(AD-A158120; AFWAL-TR-85-1041-VOL-2) Avail: NTIS HC A14/MF A01 CSCL 09B

This exploratory development program was originally aimed at developing a computer with features to specifically support the JOVIAL (J73) programming language with considerations to Ada. Later, the program was redirected to modify the instruction set architecture (ISA) to more fully support Ada and increase performance. The new ISA supports most of the standard functions found in most ISA, but gives additional supports in: the Ada package concept, processing arrays and records, unconstrained arrays, dynamic storage allocation, detecting dangling reference, detecting undefined variables, Ada-like exception handling, case instructions, for-loop instructions, Ada-like parameter passing, Ada-like tasking instructions and IEEE-standard floating point data types. GRA

**N86-12224#** General Accounting Office, Washington, D. C. National Security and International Affairs Div.
**NAVY SHOULD JOIN THE AIR FORCE AND ARMY PROGRAM TO DEVELOP AN ADVANCED INTEGRATED AVIONICS SYSTEM**
17 Jun. 1985 17 p
(PB85-222503; GAO/NSIAD-85-94; B-215379) Avail: NTIS HC A02/MF A01 CSCL 01D

Modern technology should soon enable separate avionics systems in an aircraft to be consolidated into a single package to conserve space, save weight, and reduce costs. The report points out the potential benefits of avionics consolidation and recommends the Navy join in a demonstration program now being conducted by the Air Force and Army to exploit such benefits. GRA

# 07

# AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-13051#**
**DERIVATIVE ENGINES VERSUS NEW ENGINES - WHAT DETERMINES THE CHOICE?**
D. M. DIX and D. A. GISSENDANNER (DOD, Office of the Under Secretary of Defense, Washington, DC) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 808-814.
(ASME PAPER 85-GT-190)

Attention is given to the objective factors to be considered in choosing between a new and a derivative engine for existing or new aircraft, in view of recent and current engine choice cases. An examination of the numerous factors implicit in performance capabilities, costs, and risks, leads to the identification of 12 objective factors; many of these are noted to have been previously overlooked in rational engine choice analyses. Attention is given to the cases of F-15 and F-16 reengining, powerplant selection for the Advanced Joint Services Vertical Lift Aircraft, and derivative engines for the U.S. Navy's A-6. O.C.

**A86-13053#**
**EXPERIMENTAL EVALUATION OF HEAVY FAN-HIGH-PRESSURE COMPRESSOR INTERACTION IN A THREE-SHAFT ENGINE. I - EXPERIMENTAL SETUP AND RESULTS**
A. SCHAEFFLER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) and D. C. MIATT (Rolls-Royce, Ltd., Bristol, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 828-832.
(ASME PAPER 85-GT-173)

Severe aerodynamic interaction between the fan core stream section and the high-pressure compressor of a three-shaft, low bypass ratio engine is described. At high fan running lines, a heavy single-cell rotating stall was found in the fan core stream even at high aerodynamic speeds of between 90-98 percent. The rotating circumferential distortion with 180-200 deg sector angle is swallowed by the intermediate pressure compressor, but erodes the high pressure compressor surge margin by about 22 percent, leading to steady-state surges. A remotely mounted transducer in a specific arrangement was used successfully for measurements in the hot environment behind intermediate and high pressure compressor using a 'long-line' system with a closed end at the downstream pipe. Author

**A86-13054*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**FIBER OPTICS FOR PROPULSION CONTROL SYSTEMS**
R. J. BAUMBICK (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 851-855. Previously announced in STAR as N84-14111.
(ASME PAPER 84-GT-97)

In aircraft systems with digital controls, fiberoptics has advantages over wire systems because of its inherent immunity to electromagnetic noise (EMI) and electromagnetic pulses (EMP). It also offers a weight benefit when metallic conductors are replaced by optical fibers. To take full advantage of the benefits of optical waveguides, passive optical sensors are also being developed to eliminate the need for electrical power to the sensor. Fiberoptics may also be used for controlling actuators on engine and airframe. In this application, the optical fibers, connectors, etc. will be subjected to high temperature and vibrations. This paper discussed the use of fiberoptics in aircraft propulsion systems together with the optical sensors and optically controlled actuators being developed to take full advantage of the benefits which fiberoptics offers. The requirements for sensors and actuators in advanced propulsion systems are identified. The benefits of using fiberoptics in place of conventional wire systems are discussed as well as the environmental conditions under which the optical components must operate. B.W.

**A86-13058#**
**THE DESIGN, PERFORMANCE AND ANALYSIS OF A HIGH WORK CAPACITY TRANSONIC TURBINE**
J. D. BRYCE, M. R. LITCHFIELD, and N. P. LEVERSUCH (Royal Aircraft Establishment, Farnborough, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 931-937. refs
(ASME PAPER 85-GT-15)

This paper describes the design and testing of a high work capacity single-stage transonic turbine of aerodynamic duty tailored to the requirements of driving the high-pressure core of a lowcost turbofan engine. Aerodynamic loading was high for this duty, and a major objective in the design was the control of the resulting transonic flow to achieve good turbine performance. Practical and coolable blading was a design requirement. At the design point (pressure ratio = 4.48), a turbine total-to-total efficiency of 87.0 percent was measured, based on measured shaft power and a tip clearance of 1.4 percent of blade height. In addition, the turbine was comprehensively instrumented to allow measurement of aerofoil surface static pressures on both stator and rotor; the latter being expedited via a rotating 'scanivalve' system. Downstream area traverses were also conducted. Analysis of these measurements indicates that the turbine operates at overall reaction levels lower than design, but the rotor blade performs efficiently. Author

**A86-13173**
**MATERIALS AND MANUFACTURING PROCESSES FOR ADVANCED JET ENGINES**
R. E. SCHAFRIK (USAF, Systems Command, Andrews AFB, MD) and R. WILLIAMS (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1424-1429. refs

This paper will discuss requirements and developments in materials performance, manufacturing quality, and life cycle cost for future jet engines. Advances in powered flight have always required improvements in engine technology which, in turn, has oftentimes been paced by progress in materials and manufacturing technology. In addition, man-rated aircraft demand the ultimate in propulsion system reliability. As a result, assuring quality of aeronautical engine parts and assemblies has become as important as the material properties used by the design engineer. And since the cost of owning and operating aircraft has become a key factor in selecting a system and determining the quantity to be purchased, factors such as engine durability, ease of repair, and in-service inspectability now have equal status to material performance and manufacturing quality. The impact of these three elements is playing a significant role in determining future directions for military jet aircraft engines. Author

**A86-13408**
**CRITICAL VALUES OF THE MACH NUMBER OF A RADIAL AIRFOIL CASCADE [O KRITICHESKIKH ZNACHENIIAKH CHISLA M RADIAL'NOI RESHETKI PROFILEI]**
V. A. GALAEV, N. A. ERMOLAEVA, and IU. A. ZABELIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 110-114. In Russian.

The efficiency of a turboprop engine is largely determined by the critical Mach number of the system propeller-spinner-intake. Here, the real system is replaced by a schematic radial airfoil cascade, and a numerical solution is obtained for the velocity potential describing the mean axisymmetric flow past the cascade. The solution yields an expression relating the critical Mach number to the cascade density. V.L.

**A86-13444**
**CALCULATION OF UNSTEADY FLOW IN A TWO-STAGE GAS TURBINE ENGINE [RASCHET NESTATSIONARNOGO TECHENIIA V DVUKHKONTURNOM GAZOTURBINNOM DVIGATELE]**
V. F. PAVLENKO, IU. A. SKVORTSOV, and A. S. TUTUSHKIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 114-119. In Russian. refs

The paper presents a mathematical model of a two-stage turbojet engine with an afterburner operating in a one-dimensional unsteady flow. The model, based on integral equations of gas dynamics, makes it possible to investigate gas-dynamic stability problems in such engines. Unsteady-flow parameters in the case of abrupt changes of fuel consumption in the main combustion chamber are calculated. B.J.

**A86-13447**
**DESIGN OF THE FLOW PATH OF AIRCRAFT GAS-TURBINE ENGINES [PROEKTIROVANIE PROTOCHNOI CHASTI TURBIN AVIATSIONNYKH DVIGATELEI]**
S. Z. KOPELEV Moscow, Izdatel'stvo Mashinostroenie, 1984, 224 p. In Russian. refs

The fundamentals of the theory and design of axial-flow gas turbines are presented. Attention is given to the rational selection of a particular flow-path scheme during the design of an aircraft gas-turbine engine and its gasdynamic analysis as a function of the specified parameters. The effect of the structural components of the turbine flow path on the efficiency of the turbine is demonstrated. Analytical profiling techniques using Bernoulli lemniscates are presented. V.L.

**A86-13599**
**CUMULATIVE-DAMAGE MODELING OF FATIGUE CRACK GROWTH IN TURBINE ENGINE MATERIALS**
J. M. LARSEN and T. NICHOLAS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 22, no. 4, 1985, p. 713-730. refs
(Contract AF PROJECT 2307P102)

Life predictions of turbine engine structural components utilize fracture mechanics principles to determine fatigue crack growth rates. Fatigue cracks grow under conditions of variable temperature, frequency, hold time, stress ratio and stress level. At elevated temperatures, time-dependent material behavior can play a significant role in the material behavior. Cumulative-damage models must account for all these variables as well as interaction effects. The earliest modeling involved interaction schemes and, primarily, time-independent material behavior. More recent work has focused on time-dependence and creep-fatigue interaction effects. A review of current modeling concepts is presented. Author

**A86-14226*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**SENSOR FAILURE DETECTION FOR JET ENGINES USING ANALYTICAL REDUNDANCY**
W. C. MERRILL (NASA, Lewis Research Center, Cleveland, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 673-682. Previously cited in issue 05, p. 553, Accession no. A85-16097. refs

**A86-14244#**
**RESERVE GENERATOR FOR OVER-OCEAN TWINS**
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 23, Nov. 1985, p. 26, 28.

Attention is given to the design features, performance, and operational functions of a reserve generator that has been installed in the twin-engine, transoceanic range 767-300 airliner. This generator, which serves as a second backup to engine-driven generators, is driven by a constant speed, variable-displacement servocontrolled hydraulic motor. The self-excited generator and hydraulic motor are installed in the wheel well of the aircraft. O.C.

**A86-14338*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**VIBRATION ANALYSIS OF ROTATING TURBOMACHINERY BLADES BY AN IMPROVED FINITE DIFFERENCE METHOD**
K. B. SUBRAHMANYAM and K. R. V. KAZA (NASA, Lewis Research Center, Cleveland, OH) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 21, Oct. 1985, p. 1871-1886. refs

The problem of calculating the natural frequencies and mode shapes of rotating blades is solved by an improved finite difference procedure based on second-order central differences. Lead-lag, flapping and coupled bending-torsional vibration cases of untwisted blades are considered. Results obtained by using the present improved theory have been observed to be close lower bound solutions. The convergence has been found to be rapid in comparison with the classical first-order finite difference method. While the computational space and time required by the present approach is observed to be almost the same as that required by the first-order theory for a given mesh size, accuracies of practical interest can be obtained by using the improved finite difference procedure with a relatively smaller matrix size, in contrast to the classical finite difference procedure which requires either a larger matrix or an extrapolation procedure for improvement in accuracy. Author

**A86-14358#**
**DEVELOPMENT OF MODERN TURBOPROP ENGINES**
H. I. H. SARAVANAMUTTOO (Carleton University, Ottawa, Canada) (NATO, AGARD, Specialist Meeting on Aerodynamics and Acoustics of Propellers, Toronto, Canada, Oct. 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, June 1985, p. 131-139. NSERC-supported research. refs

An evaluation is made of configurational possibilities and technology readiness considerations relevant to the design of turboprop powerplants suitable for 'propfan' propulsion of airliners, with attention to engine core performance advancements made since turboprops were last used in airliners (the late 1950s) and the critical upgrading of transmissions for the higher power levels envisaged. The technical risks foreseen suggest a channeling of initial efforts toward engines of moderate, 10,000-12,000 shp output; the goal of Mach 0.8 cruise speeds for such power plants, as set by NASA, may be overly ambitious. O.C.

**A86-14430*#** Army Propulsion Lab., Cleveland, Ohio.
**DEAN - A PROGRAM FOR DYNAMIC ENGINE ANALYSIS**
G. G. SADLER (U.S. Army, Propulsion Laboratory, Cleveland, OH) and K. J. MELCHER (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, and ASME, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 17 p. Previously announced in STAR as N85-28945. refs
(AIAA PAPER 85-1354)

The Dynamic Engine Analysis Program, DEAN, is a FORTRAN code implemented on the IBM/370 mainframe at NASA Lewis Research Center for digital simulation of turbofan engine dynamics. DEAN is an interactive program which allows the user to simulate engine subsystems as well as full engine systems with relative ease. The nonlinear first order ordinary differential equations which define the engine model may be solved by one of four integration schemes, a second order Runge-Kutta, a fourth order Runge-Kutta, an Adams Predictor-Corrector, or Gear's method for still systems. The numerical data generated by the model equations are displayed a specified intervals between which the user may choose to modify various parameters affecting the model equations and transient execution. Following the transient run, versatile graphics capabilities allow close examination of the data. DEAN's modeling procedure and capabilities are demonstrated by generating a model of simple compressor rig. Author

**A86-14528*#** General Electric Co., Cincinnati, Ohio.
**SUBSCALE-MODEL AND FULL-SCALE ENGINE MIXED-FLOW EXHAUST SYSTEM PERFORMANCE COMPARISON**
A. P. KUCHAR (General Electric Co., Advanced Engineering Technologies Dept., Cincinnati, OH) and R. CHAMBERLIN (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 950-955. Previously cited in issue 06, p. 723, Accession no. A84-17997. refs

**A86-14562#**
**SOLID FUEL RAMJET SIMULATOR RESULTS - EXPERIMENT AND ANALYSIS IN COLD FLOW**
J. RICHARDSON, W. A. DE GROOT, J. I. JAGODA, R. E. WALTERICK, J. E. HUBBARTT (Georgia Institute of Technology, Atlanta) et al. Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 488-493. Previously cited in issue 07, p. 856, Accession no. A85-19671. refs
(Contract AF-AFOSR-83-0356)

**A86-15225*** Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
**RIBBON-BURNER SIMULATION OF T-700 TURBINE SHROUD FOR CERAMIC-LINED SEALS RESEARCH**
J. K. LITTLE (USAF, Arnold Air Force Station, TN), G. P. ALLEN, G. MCDONALD, and R. C. HENDRICKS (NASA, Lewis Research Center, Cleveland, OH) . Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 6, July-Aug. 1985, p. 849-861. Previously announced in STAR as N85-19364. refs

Experimental and analytical studies were conducted to determine the acceptability of a ribbon-burner simulation of engine conditions for testing ceramic-lined turbine tip shrouds. The calculated values reveal that the ribbon burner establishes at least as harsh a thermal environment as is present at any time within the turbine shroud. Comparisons were made with ceramic components in a turboshaft engine. Author

**A86-15410**
**TEST OF JET ENGINE TURBINE BLADES BY THERMOGRAPHY**
K. DING (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: International Conference on Thermal Infrared Sensing for Diagnostics and Control (Thermosense VII), Cambridge, MA, November 5-8, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 52-56. refs

Two applications of thermography for testing and development of turbomachinery components are described. Fabrication defects in the cooling system of internally cooled turbine blades are detected by transient heating of the blade and measuring its surface temperature distribution by an infrared imaging system. Defects like blocking, narrowing, widening, and mispositioning of cooling channels can clearly be identified by the disturbance of the transient surface temperature distribution of the blade. To improve the cooling configuration of turbine blades, the cooling effectiveness over the total blade surface must be determined under test conditions similar to those in the turbomachine. The infrared measurement of blade surface temperature distributions in a hot air cascade and the method for correcting the infrared intensities for radiation reflected at the measuring surface are illustrated in an example. Author

**N86-12225** Department of the Air Force, Washington, D.C.
**COMPARTMENTED, FILAMENT WOUND, ONE-PIECE AIRCRAFT FUEL TANKS Patent**
E. J. MORRISEY, inventor (to Air Force) 16 Apr. 1985 6 p
(AD-D011793; US-PATENT-4,511,105; US-PATENT-CLASS-244-135) Avail: US Patent and Trademark Office CSCL 01C

An external aircraft fuel tank is provided which comprises a filament-reinforced fuel cell assembled with aerodynamic end shapes having a plurality of layers of adhesive resin-impregnated filament wrappings over the assembly. Also provided is a method for making the fuel tank. Author (GRA)

**N86-12227*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**FLUID MACHINES: EXPANDING THE LIMITS, PAST AND FUTURE**
M. J. HARTMANN and D. M. SANDERCOCK 1985 46 p refs
Presented at the Winter Ann. Meeting of the Am. Soc. of Mech. Eng., Miami Beach, Fla., 17-22 Nov. 1985
(NASA-TM-87161; E-2793; NAS 1.15:87161) Avail: NTIS HC A03/MF A01 CSCL 21E

During the 40 yr period from 1940 to 1980, the capabilities and operating limits of fluid machines were greatly extended. This was due to a research program, carried out to meet the needs of aerospace programs. Some of the events are reviewed. Overall advancements of all machinery components are discussed followed by a detailed examination of technology advancements in axial compressors and pumps. Future technology needs are suggested. E.A.K.

**N86-12228#** Department of the Air Force, Washington, D.C.
**IMPROVED TEMPERATURE DETECTION SYSTEM FOR USE ON FILM COOLED TURBINE AIRFOILS Patent Application**
R. FREDERICK, inventor (to Air Force) 1 May 1985 13 p
(AD-D011762; US-PATENT-APPL-SN-729388) Avail: NTIS HC A02/MF A01 CSCL 21E

This patent application discloses an improved temperature detection system for use on film cooled turbine airfoils having a showerhead assembly with a series of parallel slots defined in the leading edge of an airfoil, each slot having a multiplicity of film flow ports exiting therefrom. A plurality of sensor assemblies are affixed to the airfoil showerhead and are couplable via electrodes to electronic sensing equipment for establishing the gas flow temperature. GRA

**N86-12229#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**COMPRESSOR RESEARCH FACILITY F100 HIGH PRESSURE COMPRESSOR INLET TOTAL PRESSURE AND SWIRL PROFILE SIMULATION Final Report, Dec. 1980 - Nov. 1983**
W. W. COPENHAVER Oct. 1984 287 p
(Contract AF PROJ. 3066)
(AD-A157108; AFWAL-TR-84-2030) Avail: NTIS HC A13/MF A01 CSCL 21E

The F100 gas turbine engine currently powers the Air Force F-15 and F-16 aircraft. The compression section of this engine consists of a three-stage fan followed by a ten-stage High Pressure Compressor (HPC). A component test of the F100 HPC will be performed in the Compressor Research Facility (CRF) of the Aero Propulsion Laboratory (APL) at Wright-Patterson Air Force Base, to investigate its stall and post stall characteristics. This testing will require that the high pressure compressor entrance profiles be simulated to obtain results which correspond to actual engine operation. Since these entrance profiles had never been measured, a program was designed to experimentally measure the total and static pressure, temperature and flow angle profiles at the HPC entrance of an F100 Series 3 engine (F100 (3)), (S/NP072). The measured profile data were then used as design data for a set of inlet screens and vanes. These vanes and screens will simulate the engine fan discharge profiles for the HPC test. The manufactured screens and vanes were tested in Room 24 of Building 18 of the Air Force Wright Aeronautical Laboratories to verify their simulation capabilities. Five separate test periods were necessary to achieve the program goals. These tests are described in Sections 2 thru VI. The program discussion and conclusions are presented in Section 7 and 8. GRA

**N86-12230#** Battelle Columbus Labs., Ohio.
**COMPOSITION AND PHOTOCHEMICAL REACTIVITY OF TURBINE ENGINE EXHAUST Final Report, Mar. 1983 - Sep. 1984**
C. W. SPICER, M. W. HOLDREN, F. F. LYON, and R. M. RIGGIN Jun. 1985 52 p
(Contract F08635-82-C-0131)
(AD-A157643; AFESC/ESL-TR-84-61) Avail: NTIS HC A04/MF A01 CSCL 21B

This study was carried out to augment the results of an earlier investigation of turbine engine emissions. Experiments were conducted to investigate the photochemical reactivity and biological activity of exhaust from a full-scale 60 deg. sector combustor from a TF-39 turbine engine. All experiments were carried out at idle power setting. The study utilized exhaust from two conventional petroleum fuels (JP-4 and JP-5) and a shale fuel meeting JP-4 specifications Photochemical reactivity was studied with two large (8 cum 3)n Teflon outdoor environmental chambers. Photochemical reactivity is defined for purposes of this study as the maximum ozone concentration produced during a one day irradiation in natural sunlight. Experiments were undertaken with a TF-39 combustor operating on JP-4 and JP-5 fuels, for comparison with pervious studies of a full-scale TF-39 engine. The combustor exhaust was more effective than exhaust from the full-scale engine, regardless of which fuel was burned. The combustor exhaust was 60 percent more reactive than engine exhaust for JP-5 fuel, and between 30 and 100 percent more reactive for JP-4 fuel. The photochemical reactivity of exhaust generated from a shale oil-derived fuel meeting JP-4 specifications was studied. Exhaust from the shale fuel was no more reactive than exhaust from petroleum fuels, and under some circumstances was actually less reactive. The shale fuel exhaust also generated less secondary aerosol than exhaust from the petroleum fuels. GRA

**N86-12231#** Naval Weapons Center, China Lake, Calif.
**ANALYSIS OF PARTICULATES IN THE EXHAUST PLUME OF A J52-P3 TURBOJET ENGINE AT MILITARY POWER Interim Report, Oct. 1983 - Sep. 1984**
J. H. JOHNSON, E. D. ERICKSON, and D. J. KNIGHT Mar. 1985 27 p
(AD-A157840; AD-E900455; NWC-TP-6618) Avail: NTIS HC A03/MF A01 CSCL 21E

This report presents particulate concentration, emission index, and size distribution data in the exhaust plume of a J52-P3 turbojet engine, run at military power in the open air. Recommendations are listed for future tests. GRA

**N86-12232#** Department of the Air Force, Washington, D.C.
**LENGTH ADJUSTABLE STRUT LINK WITH LOW AERODYNAMIC DRAG Patent Application**
D. NASH, inventor (to Air Force) 10 Jul. 1985 25 p
(AD-D011851; US-PATENT-APPL-SN-753462) Avail: NTIS HC A02/MF A01 CSCL 13E

This patent application discloses a low aerodynamic drag structural link suitable for use within the housing of a turbofan jet engine. The link includes length adjustment capability, pivotal end mounting provision, maintained airstream orientation capability, low mass and jam nut length and orientation locking. Several variations in link construction including a single ball and socket arrangement, varying link cross-section along its longitudinal length and the use of fairing nose and tail inserts are disclosed. GRA

**N86-13328*#** Teledyne Continental Motors, Muskegon, Mich.
**LIGHTWEIGHT TWO-STROKE CYCLE AIRCRAFT DIESEL ENGINE TECHNOLOGY ENABLEMENT PROGRAM, VOLUME 1 Final Report, Dec. 1979 - Aug. 1985**
P. D. FREEN, S. G. BERENYI, A. P. BROUWERS, and M. E. MOYNIHAN Aug. 1985 116 p
(Contract NAS3-22218)
(NASA-CR-174923-VOL-1; NAS 1.26:174923-VOL-1) Avail: NTIS HC A06/MF A01 CSCL 21G

An experimental Single Cylinder Test Engine Program is conducted to confirm the analytically projected performance of a two-stroke cycle diesel engine for aircraft applications. The test engine delivered 78kW indicated power from 1007cc displacement, operating at 3500 RPM on Schnuerle loop scavenged two-stroke cycle. Testing confirms the ability of a proposed 4-cylinder version of such an engine to reach the target power at altitude, in a highly turbocharged configuration. The experimental program defines all necessary parameters to permit design of a multicylinder engine for eventual flight applications; including injection system requirement, turbocharging, heat rejection, breathing, scavenging, and structural requirements. The multicylinder engine concept is configured to operate with an augmented turbocharger, but with no primary scavenge blower. The test program is oriented to provide a balanced turbocharger compressor to turbine power balance without an auxiliary scavenging system. Engine cylinder heat rejection to the ambient air has been significantly reduced and the minimum overall turbocharger efficiency required is within the range of commercially available turbochargers. Analytical studies and finite element modeling is made of insulated configurations of the engines - including both ceramic and metallic versions. A second generation test engine is designed based on current test results. Author

**N86-13329*#** Teledyne Continental Motors, Muskegon, Mich.
**LIGHTWEIGHT TWO-STROKE CYCLE AIRCRAFT DIESEL ENGINE TECHNOLOGY ENABLEMENT PROGRAM, VOLUME 2 Final Report, Dec. 1979 - Aug. 1985**
P. D. FREEN, S. G. BERENYI, A. P. BROUWERS, and M. E. MOYNIHAN Aug. 1985 150 p refs
(Contract NAS3-22218)
(NASA-CR-174923-VOL-2; NAS 1.26:174923-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 21G

An experimental Single Cylinder Test Engine Program is conducted to confirm the analytically projected performance of a two-stroke cycle diesel engine for aircraft applications. Testing confirms the ability of a proposed 4-cylinder version of such an engine to reach the target power at altitude in a highly turbocharged configuration. The experimental program defines all necessary parameters to permit a design of a multicylinder engine for eventual flight applications. Author

**N86-13330*#** Teledyne Continental Motors, Muskegon, Mich.
**LIGHTWEIGHT TWO-STROKE CYCLE AIRCRAFT DIESEL ENGINE TECHNOLOGY ENABLEMENT PROGRAM, VOLUME 3 Final Report, Dec. 1979 - Aug. 1985**
P. D. FREEN, S. G. BERENYI, A. P. BROUWERS, and M. E. MOYNIHAN Aug. 1985 282 p
(Contract NAS3-22218)
(NASA-CR-174923-VOL-3; NAS 1.26:174923-VOL-3) Avail: NTIS HC A13/MF A01 CSCL 21G

An experimental Single Cylinder Test Engine Program is conducted to confirm the analytically projected performance of a two-stroke cycle diesel engine for aircraft applications. Testing confirms the ability of a proposed 4-cylinder version of such an engine to reach the target power at altitude in a highly turbocharged configuration. The experimental program defines all necessary parameters to permit design of a multicylinder engine for eventual flight applications. Author

**N86-13331#** Massachusetts Inst. of Tech., Cambridge. Dept. of Ocean Engineering.
**HUB EFFECTS IN PROPELLER DESIGN AND ANALYSIS**
M. H. WANG Jul. 1985 183 p
(Contract N00014-82-K-0198)
(AD-A158853; OE-85-14) Avail: NTIS HC A09/MF A01 CSCL 20D

A numerical model is established for the design of propeller blade shape for a prescribed circulation and a given hub geometry. The vortex lattice approach is adapted for blades and their wakes. The hub is represented by a distribution of dipoles which ends at the hub apex. It is shown that consideration of the hub results in a lower pitch and lower camber at the inner radii. An iterative method is developed for analyzing the interference between the blades and the hub. It is shown that the circulation at the root of a propeller with a hub is larger than the circulation at the root of a propeller without a hub. Two examples show that the increase in thrust due to hub effects has the same order of magnitude as the drag force effects on the hub for propellers which are moderately loaded at the hub. Experiments are carried out for comparison with the numerical results. Excellent agreement is obtained in the circulation distribution for a conventional propeller, and fair agreement for a controllable pitch propeller. Experimental results show what the circulation is, roughly speaking, conserved. A method for estimating the drag force of the hub due to the hub vortex is established by assuming that the circulation is conserved. GRA

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-13355**
**ESTIMATION OF THE PROBABILITY OF A FLIGHT PARAMETER EXCEEDING A SPECIFIED VALUE UNDER CONDITIONS OF ATMOSPHERIC TURBULENCE [OTSENKA VEROIATNOSTI PREVYSHENIIA PARAMETROM POLETA ZADANNOGO ZNACHENIIA PRI DEISTVII ATMOSFERNOI TURBULENTNOSTI]**
I. N. TITOVSKII and I. G. KHVOSTOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 74-81. In Russian. refs

The problem of the estimation of the probability of a flight parameter exceeding a specified value due to atmospheric turbulence is solved in the linear approximation using a continuous turbulence model and the stochastic process overshoot theory. A method is proposed for determining the probability of a parameter exceeding a specified value at least once during one hour of flight or per flight path unit length. The method also makes it possible to determine the average number of such overshooots per flight. V.L.

**A86-13365**
**ESTIMATION OF THE DEVIATION LIMITS OF THE AIRCRAFT PATH PARAMETERS DURING AUTOMATIC LANDING [OTSENKA PREDEL'NYKH OTKLONENII PARAMETROV TRAEKTORII SAMOLETA PRI AVTOMATICHESKOI POSADKE]**
V. P. KUZMIN and V. A. IAROSHEVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 43-56. In Russian.

A method is proposed for specifying the worst-case longitudinal wind parameters during the automatic leveling-out of aircraft in order to estimate the deviation limits of the aircraft path parameters (the vertical velocity and the flight range) at the moment of touchdown corresponding to a low specified probability level (10 to the -5th - 10 to the -7th). The method proposed here is used to study the automatic landing of typical passenger aircraft. V.L.

**A86-13370**

### A STUDY OF FLUTTER ON THE BASIS OF FREQUENCY TESTS AT SUBCRITICAL REGIMES [ISSLEDOVANIE FLATTERA NA OSNOVE CHASTOTNYKH ISPYTANII PRI DOKRITICHESKIKH REZHIMAKH]

B. D. BRIANTSEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 100-108. In Russian. refs

Algorithms are presented for deriving equations describing the vibrations of an elastic flight vehicle in air flow and for estimating the flutter characteristics from frequency tests at flow velocities that are substantially less than the critical flutter velocity. Analytical and experimental data are then presented to illustrate the possibilities afforded by the algorithms proposed here and their advantages over other methods of critical flutter velocity estimation. V.L.

**A86-13394**

### CERTAIN CRITERIA AND FORMULAS FOR THE ANALYSIS OF FLEXURAL-TORSIONAL FLUTTER [NEKOTORYE KRITERII I FORMULY DLIA ANALIZA IZGIBNO-KRUTIL'NOGO FLATTERA]

G. A. BULYCHEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 143-150. In Russian.

Criteria and formulas are derived for the parametric investigation of flexural-torsional flutter on the basis of an analysis of the modes and frequencies of the natural vibrations. The usefulness of the expressions obtained is demonstrated by using them to evaluate the flutter characteristics of a large-aspect-ratio straight wing. Results are presented in graphical form. V.L.

**A86-13417**

### MINIMIZATION OF AIRCRAFT FLIGHT TIME FOR A GIVEN DISTANCE WITH RETURN TO THE ORIGINAL POINT [MINIMIZATSIIA VREMENI POLETA SAMOLETA NA ZADANNUIU DAL'NOST' S VOZVRASHCHENIEM V ISKHODNUIU TOCHKU]

V. F. ILLARIONOV and V. T. PASHINTSEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 54-67. In Russian. refs

An approximate approach is used to consider the problem of minimizing the flight time of an aircraft with a fixed fuel supply for a given distance with return to the original point. The optimal flight profile is constructed on the basis of the standard energy method with variation of only one parameter having a physical significance. A description is given of a method for determining the saddle points of a family of extrema corresponding either to steady-state flight regimes or to singular thrust-control regimes. A numerical example concerning flight at a constant altitude is given. B.J.

**A86-13435**

### METHOD FOR CALCULATING THE EQUILIBRIUM SPIN OF AN AIRCRAFT [METOD RASCHETA USTANOVIVSHEGOSIA DVIZHENIIA SAMOLETA PO SPIRALI]

V. K. SVIATODUKH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 51-62. In Russian. refs

Equations for the equilibrium spin of an aircraft are obtained in a form containing the angle of attack alpha, the sideslip angle beta, the direction cosines of the vertical, and the parameter (omega) (V)/g, where omega is the angular velocity and V is the modulus of the center-of-mass velocity. The direction cosines of the vertical are determined as explicit functions of alpha, beta, and (omega)(V)/g in the case when the aerodynamic forces do not depend on the angular velocities of the aircraft. In this case the complete equations of equilibrium motion are reduced to three moment equations depending on the above three variables. A method for the approximate determination of the dependence of the aerodynamic forces on the angular velocities of the aircraft is proposed. B.J.

**A86-13436**

### CALCULATION OF EQUILIBRIUM TURN [RASCHET USTANOVIVSHEGOSIA VIRAZHA]

A. A. SHILOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 63-70. In Russian.

A method is developed for calculating the characteristics of such motions of an aircraft as equilibrium turn, descending turn, and equilibrium spin. Particular attention is given to the structure of the kinematic and dynamic equations used to solve the problem for arbitrary aerodynamic characteristics of the aircraft. B.J.

**A86-13931**

### DYNAMICS OF NON-AUTONOMOUS SPATIAL MOTION OF AN AEROPLANE WITH DEFORMABLE CONTROL SYSTEMS

Z. DZYGADLO and A. KRZYZANOWSKI Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 1, 1984, p. 53-77. refs

The dynamics of nonautonomous spatial motion of an aircraft with deformable control systems and moving ponderable control surfaces is analyzed. A complete nonlinear set of equations of spatial motion is derived, introducing time-dependent external forces and taking into account the elasticity and damping in the control systems and the unbalance of the ailerons, the elevator, and the rudder. A program for the numerical integration of the equations by the Runge-Kutta-Gill method is used. The effect of external forces on the dynamics of the aircraft's spatial motion is studied. The influence of stiffness and damping in the controls is investigated with a numerical resonance analysis of the oscillating control surface. C.D.

**A86-14235#**

### LONGITUDINAL STABILITY OF A HOVERING, TETHERED ROTORCRAFT

D. C. RYE (Sydney, University, Australia) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 743-752. refs

Linearized equations describing the perturbed longitudinal motion of a tethered rotorcraft are presented. The tethering cable is assumed to be straight and inextensible. This permits development of two degree-of-freedom equations which admit cable tension variations. Routh's criteria are applied to a simplified stability quartic for hovering flight in an analytic search for stable configurations. The cable length, equilibrium tension, and point of attachment strongly influence the stability of perturbed motion. If the cable is short, the machines considered may be inherently stable. This does not appear to be possible for hovering flight on very long cables. Numerical solutions to the complete stability quartic show good agreement with approximate Routh's-criteria predictions. Author

**A86-14236*#** Princeton Univ., N. J.

### STABILITY AND CONTROL OF VTOL CAPABLE AIRSHIPS IN HOVERING FLIGHT

H. C. CURTISS, JR. (Princeton University, NJ) and V. SUMANTRAN Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 753-760. refs

(Contract NAG2-98)

The stability and control characteristics of an airship equipped with lifting rotors to provide a modest VTOL capability are discussed. The rotors are used for control and maneuvering in near-hovering flight. Configurations with two, three, and four lifting rotors are examined and compared with respect to control capabilities and dynamic response characteristics. Linearized models of the dynamics are employed for this study. A new approach to the prediction of rotor derivatives for operation near zero thrust in hover is presented. It is found that all three configurations have similar control and response characteristics. The responses are characterized by long time constants and low levels of angular damping. Author

**A86-14243#**

**A SELF-REPAIRING AIRCRAFT?**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 23, Nov. 1985, p. 22, 24.

Attention is given to a computer program which will allow future control-configured fighter aircraft to automatically compensate for the loss of a control surface due to combat damage, in order to maintain stability. Such a system, if successfully implemented, would also be able to compensate for electronic and hydraulic system failures, effectively obviating the presently critical requirement for four-fold redundancy in such systems. This would reduce cost and complexity, while increasing MTBF. The reliable detection of system failures is identified as a major problem in implementation. O.C.

**A86-14530*#** California Univ., Los Angeles.

**AEROMECHANICAL STABILITY ANALYSIS OF A HYBRID HEAVY LIFT MULTIROTOR VEHICLE IN HOVER**

C. VENKATESAN and P. P. FRIEDMANN (California, University, Los Angeles) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 251-265) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 965-972. Previously cited in issue 13, p. 1836, Accession no. A84-31712. refs
(Contract NAG2-116)

**A86-14531*#** Flight Systems, Inc., Newport Beach, Calif.

**IMPACT OF FLYING QUALITIES ON MISSION EFFECTIVENESS FOR HELICOPTER AIR COMBAT**

T. M. HARRIS, D. A. BEERMAN (Flight Systems, Inc., Newport Beach, CA), and C. C. BIVENS (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 973-978. Previously cited in issue 20, p. 2855, Accession no. A84-42354. refs
(Contract NAS2-11178)

**A86-14533#**

**FREE-FALLING AUTOROTATING PLATE - A COUPLED FLUID AND FLIGHT MECHANICS PROBLEM**

C. R. GALLAWAY and W. L. HANKEY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 983-987. Previously cited in issue 20, p. 2854, Accession no. A84-42336. refs

**A86-14534#**

**THE NUMERICAL COMPUTATION OF AIRCRAFT RESPONSE TO ARBITRARY VERTICAL GUST DISTRIBUTIONS**

J. AN (Chinese Aerodynamic Research and Development Centre, Mianyang, People's Republic of China), Z. YAN, W. ZHOU (Jiaotong University, Shanghai, People's Republic of China), and C. QIU (Shanghai Aircraft Co., People's Republic of China) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 988-992. Previously cited in issue 20, p. 2854, Accession no. A84-42331. refs

**N86-12233*#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.

**INTERACTIVE AIRCRAFT FLIGHT CONTROL AND AEROELASTIC STABILIZATION Semiannual Report, 1 May - 31 Oct. 1985**

T. A. WEISSHAAR Nov. 1985 48 p refs
(Contract NAG1-157)
(NASA-CR-176323; NAS 1.26:176323) Avail: NTIS HC A03/MF A01 CSCL 01C

Aeroservoelastic optimization techniques were studied to determine a methodology for maximization of the stable flight envelope of an idealized, actively controlled, flexible airfoil. The equations of motion for the airfoil were developed in state-space form to include time-domain representations of aerodynamic forces and active control. The development of an optimization scheme to stabilize the aeroelastic system over a range of airspeeds, including the design airspeed is outlined. The solution approach was divided in two levels: (1) the airfoil structure, with a design variable represented by the shear center position; and (2) the control system. An objective was stated in mathematical form and a search was conducted with the restriction that each subsystem be constrained to be optimal in some sense. Analytical expressions are developed to compute the changes in the eigenvalues of the closed-loop, actively controlled system. A stability index is constructed to ensure that stability is present at the design speed and at other airspeeds away from the design speed. E.A.K.

**N86-12234#** Aeronautical Research Labs., Melbourne (Australia).

**FLUTTER CLEARANCE TESTS ON A TRANSAVIA PL-12/T-400 SKYFARMER**

A. GOLDMAN and S. GALEA Mar. 1985 66 p
(AD-A157212; ARL/STRUC-TM-400) Avail: NTIS HC A04/MF A01 CSCL 20D

The Transavia T-400 Skyfarmer is the latest version of the twin-boom agricultural aircraft and incorporates several changes from the T-300 model previously tested. Changes which could affect the flutter characteristics are: (1) Change of engine from 6 cylinder 300 horsepower to 8 cylinder 400 horsepower; (2) Increase in length of tail booms by 750 mm; (3) Increase in stub-wing span by 900 mm; (4) Removal of the spring-tab from the elevators; and (5) Addition of a dorsal stabilizer fin along each tail boom. A ground resonance test and subsequent flight tests were conducted on a Transavia T-400 Skyfarmer. The natural modes and frequencies of vibration were measured in the ground tests, and monitored during flight tests in which attempts were made to induce flutter. The results of these tests are presented. GRA

**N86-12235#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**POST STALL MANEUVERS AND THRUST VECTORING PERFORMANCE ANALYSIS Final Technical Report, Aug. 1983 - Jul. 1984**

L. E. MILLER Jul. 1984 77 p
(Contract AF PROJ. 2404)
(AD-A158100; AFWAL-TR-84-3109) Avail: NTIS HC A05/MF A01 CSCL 01B

The purpose of this effort was to determine whether or not there are any apparent performance improvements through post stall maneuvers (PSM) or thrust vectoring. The PSM is a result of high angles of attack, greater than the stall value. Two different problems were addressed. The first examined instantaneous turning performance. The second focused on minimum time turn problems. The impact of both vectored and nonvectored thrust was considered. It was proven that minimum time turns fall in the vertical plane. For maximum instantaneous turning rate and nonvectored thrust high angle of attack results if the speed is less than the critical speed which is approximately Mach 0.2. The optimal angle of attack approaches 90 deg as the speed approaches zero. For vectored thrust, the stall angle of attack is optimum and the thrust vector angle is the complement of the angle of attack. The PSM is not optimal if thrust vectoring is available. For minimum time turning performance, maximum thrust is optimal. At the end of the trajectory, the optimal angle of attack equals that for maximum instantaneous performance. The PSM is optimal. As the thrust to weight ratio increases, the maximum angle of attack increases. GRA

**N86-12236#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**AN APPLICATION OF ADAPTIVE LEARNING TO MALFUNCTION RECOVERY M.S. Thesis**

R. E. CRUZ 1985 51 p
(AD-A158129; AFIT/CI/NR-85-85T) Avail: NTIS HC A04/MF A01 CSCL 01D

A self-organizing controller was developed for a simplified two-dimensional aircraft model. The controller learns how to pilot the aircraft through a navigational mission without exceeding pre-established position and velocity limits. The controller pilots the aircraft by activating one of eight directional actuators at all times. By continually monitoring the aircraft's position and velocity with respect to the mission, the controller progressively modifies its decision rules to improve the aircraft's performance. When the controller has learned how to pilot the aircraft, two actuators fail permanently. Despite this malfunction, the controller regains proficiency at its original task. The experimental results reported show the controller's capabilities for self-organizing control, learning, and malfunction recovery. GRA

**N86-12405#** Joint Publications Research Service, Arlington, Va.
**JAPANESE REPORT ON CHINA'S F-8 FIGHTER**
Y. YUEBO *In its* China Rept.: Sci. and Technol. (JPRS-CST-85-035) p 70-72 17 Oct. 1985 Transl. into ENGLISH from Hangkong Zhishi (Beijing), no. 7, Jul. 1985 p 22-23
Avail: NTIS HC A08/MF A01

A new Chinese-built fighter aircraft has been unveiled. This aircraft, which is named the F-8, has a delta wing and a horizontal tail; it probably has two engines, and its maximum speed is estimated to be greater than Mach2. According to the article 1983-1984 Military Balance, approximately thirty F-8 aircraft are currently in service in the Chinese Air Force. G.L.C.

**N86-13332*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A PRELIMINARY EVALUATION OF THE GENERALIZED LIKELIHOOD RATIO FOR DETECTING AND IDENTIFYING CONTROL ELEMENT FAILURES IN A TRANSPORT AIRCRAFT**
W. T. BUNDICK Sep. 1985 94 p refs
(NASA TM-87620; NAS 1.15:87620) Avail: NTIS HC A05/MF A01 CSCL 01C

The application of the Generalized Likelihood Ratio technique to the detection and identification of aircraft control element failures has been evaluated in a linear digital simulation of the longitudinal dynamics of a B-737 aircraft. Simulation results show that the technique has potential but that the effects of wind turbulence and Kalman filter model errors are problems which must be overcome. Author

**N86-13334#** Air Force Academy, Colo.
**PITCH RATE VERSUS G COMMAND AS THE LONGITUDINAL FLIGHT CONTROL SYSTEM DESIGN STRATEGY FOR A STATISTICALLY UNSTABLE FIGHTER TYPE AIRCRAFT WITH TWO CONTROL SURFACES**
T. P. WEBB 2 Jul. 1985 32 p
(AD-A158803; USAFA-TN-85-8) Avail: NTIS HC A03/MF A01 CSCL 01D

Pitch rate command and normal G command longitudinal flight control systems were designed using linear optimal control theory for a statically unstable, two control surface, fighter-type aircraft at both a power approach and an up-and-away flight condition. The closed-loop systems were then evaluated in man-in-the-loop simulations with pilots attempting random altitude tracking and pitch tracking tasks. The evaluation results indicated that in the power approach flight condition, normal G command was more suitable for altitude tracking and pitch rate command was preferred for pitch tracking. Results for the up-and-away flight condition were inconclusive. GRA

**N86-13335#** Southwest Research Inst., San Antonio, Tex.
**DIGITAL SERVOCONTROLLER SYSTEM. VOLUME 4. RESULTS AND CONCLUSIONS Final Report, Jul. 1983 - Nov. 1984**
J. LOPEZ and K. MILLER Feb. 1985 31 p
(AD-A159068; SWRI-14-7676-VOL-4; AFWAL-TR-84-3117-VOL-4)
Avail: NTIS HC A03/MF A01 CSCL 09B

This final report describes an exploratory development effort for the design and fabrication of a digital servocontroller system for load control in full-scale air-frame fatigue tests. Each digital controller replaces four analog controllers. The LSI-11/23 microcomputer in the digital controller executes a PI algorithm to implement direct digital control. It may operate in a stand-alone mode or as a slave processor to a master computer via fiber optic link. Other programmable features specify loop parameters, building load profiles, adjusting control system gains and monitoring alarm and abort conditions. GRA

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-13214**
**GRUMMAN'S AUTOMATED TEST SYSTEMS**
C. SCHIANO (Grumman Data Systems Corp., Calverton, NY) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 147-154.

Attention is given to the features and functions of a proprietary Automated Test System (ATS) that has been successfully used to support aircraft test data processing. The ATS consists of a complement of hardware and software subsystems which, when combined with a central processor, yield the integrated system capabilities required for real time/on-line test analyses. Interactive data processing of telemetered, range-acquired, and data base-generated test data furnishes real time answers to development engineer's questions. Development histories are given for the initial (1970-1983) and current (1983-1986) configurations of the ATS, as well as projected features for the 1987-1990s time frame. O.C.

**A86-13248**
**CANADIAN FORCES PCM TELEMETRY PROCESSING AND DISPLAY SYSTEM**
L. B. GLENESK and J. L. MARRIOTT (Aerospace Engineering Test Establishment, Medley, Canada) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 593-602.

The Canadian Forces Flight Test Facilities are described, and planned enhancements are examined. The facilities consist of the Aerospace Engineering Test Establishment (AETE) which includes the 200 square mile Primrose Lake Evaluation Range, 300 km east-northeast of Edmonton, Alberta. The facilities at PLER include nine phototheodolites, a telemetry tracking and receiving station, a meteorological station, command and control centers, and microwave and L-Band telemetry link to the main AETE facilities 50 km to the south. A new ground-based PCM telemetry processing and display system is described. D.H.

**A86-13400**
**DIFFUSER PARAMETER OPTIMIZATION FOR LOW REYNOLDS NUMBERS USING EXPERIMENTAL DATA [OPTIMIZATSIIA PARAMETROV DIFFUZOROV PRI MALYKH CHISLAKH REINOL'DSA S ISPOL'ZOVANIIEM EKSPERIMENTAL'NYKH DANNYKH]**
A. P. FILATOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 38-45. In Russian. refs

Pressure recovery in the diffuser of a wind tunnel has been investigated for Mach 4.4-8.5 and Re = 1300-7600 without models and with spherical models with model-to-nozzle cross-section ratios of 0.004-0.062. Semiempirical expressins are obtained which relate the optimum geometrical parameters of the diffuser throat, pressure recovery coefficients, and optimum diffuser efficiency to the Mach number at the nozzle exit section, and the relative cross-sectional area of the model. V.L.

**A86-13405**

### USING SUCTION FOR INCREASING MACH NUMBERS IN A PERFORATED TEST SECTION WITH A SUBSONIC NOZZLE [ISPOL'ZOVANIE OTSOSA DLIA UVELICHENIIA CHISEL M V PERFORIROVANNOI RABOCHEI CHASTI S DOZVUKOVYM SOPLOM]

S. IU. BORISOV and Z. G. PASOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 93-98. In Russian.

It is shown that in the transonic perforated test section of a wind tunnel with a subsonic nozzle, Mach numbers up to 1.5 can be achieved by installing the panels of the test section at an angle of 1 deg 40 min and using suction. The suction coefficient does not exceed 8-10 percent, and there is practically no longitudinal pressure gradient in the vicinity of the model. V.L.

**A86-13428**

### INFLUENCE OF UNSTEADY FLOW EFFECTS ON THE LENGTH OF OPERATION OF A HYPERSONIC SHOCK TUNNEL [VLIIANIE NESTATSIONARNYKH EFFEKTOV TECHENIIA NA PRODOLZHITEL'NOST' RABOTY GIPERZVUKOVOI UDARNOI TRUBY]

V. L. GRIGORENKO, A. M. NAUMOV, and N. I. KHVOSTOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 149-155. In Russian. refs

Unsteady flow processes are considered in a hypersonic shock wind tunnel where Mach numbers of 5-20 are achieved. This flow is analyzed numerically for a wide range of governing parameters in a quasi-one-dimensional framework using a mobile variable-step computational grid with identification of the main discontinuities and high-gradient regions of gas parameters. An algorithm is developed for considering the effect of unsteady flow processes in the nozzle on the length of operation of a shock wind tunnel. B.J.

**A86-13443**

### SUBSONIC THERMAL WIND TUNNEL WITH AN EIFFEL CHAMBER [DOZVUKOVAIA TEPLOVAIA AERODINAMICHESKAIA TRUBA S KAMEROI EIFELIA]

A. M. BESPALOV, L. A. VNUKOVA, A. S. KROKHIN, and A. G. MIKHALCHENKO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 110-113. In Russian.

The paper gives a description of an ejector-type subsonic thermal wind tunnel with an Eiffel chamber. The wind tunnel is intended for measurements of friction distribution and viscous-flow structure on models using laser-knife, paint-drop-dispersion, and thermal-coating techniques. B.J.

**A86-13848**

### THE RIGHT COMBINATION UNLOCKS AEROSPACE EMC

O. B. M. PIETERSEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Microwaves & RF (ISSN 0745-2993), vol. 24, Oct. 1985, p. 73-76. refs

It is pointed out that aerospace vehicles present a difficult challenge for the designer concerned with electromagnetic compatibility (EMC). The requirement to keep electromagnetic interference (EMI) at acceptable levels makes it necessary to utilize a combination of empirical and computer-aided techniques. Generally, one of two basic approaches is used to ensure EMC. The specification-based approach relies on compliance with EMI specifications for each subsystem, while in the computer-aided approach, the designer predicts undesirable situations by calculations. A number of specifications are available to provide procedures for EMC testing of aerospace electronics systems and subsystems. Attention is given to transducers for EMI measurements, the major aerospace EMI specifications, EMI testing of large equipment, and the sample compatibility matrix. G.R.

**A86-14246*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### SIMULATION WORLD MOVES UP TO V/STOL

A. M. COOK (NASA, Ames Research Center, Moffett Field, CA) Aerospace America (ISSN 0740-722X), vol. 23, Nov. 1985, p. 46-48.

NASA-Ames' Vertical Motion Simulator (VMS) is a large motion amplitude manned simulator designed for investigation of landing, takeoff, and general handling qualities and control system development for STOL and VTOL aircraft. The VMS incorporates six degrees of freedom, a four-window computer-generated imagery (CGI) system, and interchangeable cabs. The CGI generates day and night scenes that can include moving objects on the ground and in flight. A project is now underway to upgrade the VMS for research on rotorcraft engaged in nap-of-the-earth flight missions. O.C.

**A86-14480#**

### ENGINE SIMULATOR TECHNIQUES FOR SCALED TEST CELL STUDIES

J. D. LEE and R. J. FREULER (Ohio State University, Columbus) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-11, 1985. 7 p. Research supported by the General Electric Co. refs
(AIAA PAPER 85-1282)

Research studies with scale model engine test cells for studying test cell aerodynamics, acoustics, and cell flow characteristics affecting engine performance have required the simulation of a variety of jet engines in accurate detail. Simulators of turboshaft engines (without propellers), low-bypass afterburning turbojets, and high-bypass turbofans were designed, fabricated and successfully operated using high-pressure air ejector systems for the motive power. The peculiar problems associated with such engine simulators and the methods used to attack these problems are described. This paper also outlines the specific designs used for four engine simulators. Author

**A86-14532#**

### IMPROVED DRAG ELEMENT FOR WIND TUNNEL STING BALANCES

M. RINGEL and D. LEVIN (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 979-982. refs

The adverse relation between sensitivity and stiffness in wind tunnel internal sting balance design leads to solutions with high nonlinear interactions. Attention is presently given to a solution in which these interactions are minimized, and for which calibration results indicate an order-of-magnitude improvement in normal force interaction linearity as well as a 60 (or more) percent improvement in moment of interaction linearity. The novel sting balance design obtained on the basis of this method allows a higher sensitivity level of the drag output, with increased overall stiffness, to be obtained. O.C.

**A86-15526**

### RADIO FREQUENCY CHAMBER IMPROVES LAMPS MK III TESTING

J. B. SCHULTZ Defense Electronics (ISSN 0278-3479), vol. 17, Nov. 1985, p. 53, 54, 56.

Attention is given to the design features, performance capabilities, and prospective applications of an RF test chamber which allows ground facility-based acceptance trials of military helicopter avionics to be conducted prior to flight testing in a highly controlled (indoor) environment. Tests encompass electromagnetic environment response and security and cryptological measures, with round-the-clock operations requiring minimum preparation time and fast recuperation from operational failures. The LAMPS Mk III antisubmarine warfare helicopter is currently undergoing tests; future testing is anticipated to involve the U.S. Navy V-22 tilt-rotor and U.S. Army LHX helicopter programs. O.C.

**N86-12237*#** College of William and Mary, Williamsburg, Va. Dept. of Computer Science.
**USER'S GUIDE TO STIPPAN: A PANEL METHOD PROGRAM FOR SLOTTED TUNNEL INTERFERENCE PREDICTION Report, 16 Mar. - 15 Jun. 1985**
W. B. KEMP, JR. 5 Nov. 1985 33 p refs
(Contract NCC1-69)
(NASA-CR-178003; NAS 1.26:178003) Avail: NTIS HC A03/MF A01 CSCL 14B

Guidelines are presented for use of the computer program STIPPAN to simulate the subsonic flow in a slotted wind tunnel test section with a known model disturbance. Input data requirements are defined in detail and other aspects of the program usage are discussed in more general terms. The program is written for use in a CDC CYBER 200 class vector processing system. Author

**N86-12238*#** Vigyan Research Associates, Inc., Hampton, Va. Dept. of Aeronautics and Astronautics.
**INTRODUCTION TO CRYOGENIC WIND TUNNELS**
M. J. GOODYER (Southampton Univ.) Sep. 1985 14 p refs
(Contract NAS1-17919)
(NASA-CR-177966; NAS 1.26:177966; AGARD-722-PAPER-1)
Avail: NTIS HC A02/MF A01 CSCL 14B

The background to the evolution of the cryogenic wind tunnel is outlined, with particular reference to the late 60's/early 70's when efforts were begun to re-equip with larger wind tunnels. The problems of providing full scale Reynolds numbers in transonic testing were proving particularly intractible, when the notion of satisfying the needs with the cryogenic tunnel was proposed, and then adopted. The principles and advantages of the cryogenic tunnel are outlined, along with guidance on the coolant needs when this is liquid nitrogen, and with a note on energy recovery. Operational features of the tunnels are introduced with reference to a small low speed tunnel. Finally the outstanding contributions are highlighted of the 0.3-Meter Transonic Cryogenic Tunnel (TCT) at NASA Langley Research Center, and its personnel, to the furtherance of knowledge and confidence in the concept. Author

**N86-12239*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**WIND TUNNEL TURNING VANES OF MODERN DESIGN**
T. F. GELDER, R. D. MOORE, J. M. SANZ, and E. R. MCFARLAND 1985 23 p refs Proposed for presentation at the 24th Aerospace Sci. Meeting, Reno, Nev., 6-8 Jan. 1986; sponsored by AIAA
(NASA-TM-87146; E-2775; NAS 1.15:87146; AIAA-86-0044)
Avail: NTIS HC A02/MF A01 CSCL 14B

Rehabilitation of the Altitude Wind Tunnel includes the need for new corner turning vanes to match its upgraded performance. The design and experimental performance results from a 0.1-full scale model of the highest speed corner ($M = 0.35$) are presented and discussed along with some two dimensional inviscid analyses of two vaned corners. With a vane designed by an inverse two dimensional technique, the overall corner loss was about 12% of the inlet dynamic pressure of which about 4% was caused by vane skin friction. Comparable values with a conventionally designed circular arc vane were about 14% overall with about 7% due to skin friction. E.A.K.

**N86-12240*#** College of William and Mary, Williamsburg, Va.
**WALL-INTERFERENCE ASSESSMENT IN THREE-DIMENSIONAL SLOTTED-WALL WIND TUNNELS Final Technical Report, 16 Jun. 1982 - 15 Oct. 1985**
W. B. KEMP, JR. Oct. 1985 11 p refs
(Contract NCC1-69)
(NASA-CR-176320; NAS 1.26:176320) Avail: NTIS HC A02/MF A01 CSCL 14B

The development of the slotted tunnel simulator code and lessons learned from its use are summarized. The high order panel method was selected as the basic procedure for aerodynamic computations. The panel singularities are supplemented by line sources to represent discrete wall slots. G.L.C.

**N86-12241#** Federal Aviation Administration, Washington, D.C. Associate Administrator for Airports.
**REPORT OF ACCOMPLISHMENTS UNDER THE AIRPORT IMPROVEMENT PROGRAM Annual Report, period ending 30 Sep. 1984**
V. J. MARTIN 30 Sep. 1984 125 p
(AD-A156834; AD-E301723; FAA-ARP-85-1; FAA-ARP-11; AR-3)
Avail: NTIS HC A06/MF A01 CSCL 01E

Section 521 of the Airport and Airway Improvement Act of 1982 (Public Law 97-248) requires that the Secretary of Transportation submit an annual report to Congress describing the accomplishments of the airport grant program. This report covers activities for the fiscal year ending September 30, 1984. Author (GRA)

**N86-12242#** Florida Univ., Gainesville. Dept. of Civil Engineering.
**CBR (CALIFORNIA BEARING RATIO) DESIGN OF FLEXIBLE AIRFIELD PAVEMENTS WITH CASE STUDY M.S. Thesis**
T. M. DESTAFNEY 1985 94 p
(Contract N66314-72-A-3029)
(AD-A158101) Avail: NTIS HC A05/MF A01 CSCL 13B

It is the purpose of this paper to state the fundamentals involved in the design of flexible airfield pavements utilizing the U.S. Army Corps of Engineers CBR (California Bearing Ratio) design method. This paper also discusses concepts that are considered to be prerequisites to any discussion of the subject, including basic pavement theory, aircraft loading effects, subgrade strength, and aircraft characteristics related to design. The CBR method of design is outlined, and an actual design performed in order to more clearly illustrate this method of designing flexible airfield pavements. GRA

**N86-13337#** Aeronautical Research Labs., Melbourne (Australia).
**ALGORITHMS FOR THE REDUCTION OF WIND-TUNNEL DATA DERIVED FROM STRAIN GAUGE FORCE BALANCES**
B. D. FAIRLIE 1985 49 p refs
(ARL/AERO-R-164; AR-004-017) Avail: NTIS HC A03/MF A01

Algorithms and procedures are presented for the reduction of force and moment data derived from wind-tunnel models supported by internal strain-gauge balances. The algorithms are developed in their most general forms, suitable for implementation on the new generation of powerful minicomputers currently being included in wind-tunnel data acquisition systems. Although the emphasis is on the treatment of data derived from sting mounted strain gauge force balances, the analysis is applicable, with only minor modifications, to data derived from modern load-cell based external force balances. Author

**N86-13339#** Air Force Engineering and Services Center, Tyndall AFB, Fla. Engineering and Services Lab.
**A DURABLE AIRFIELD MARKING SYSTEM Final Report, 23 Jun. 1980 - 30 Sep. 1984**
T. NOVINSON Jun. 1985 52 p
(Contract AF PROJ. 2054)
(AD-A157953; AFESC/ESL-TR-84-59) Avail: NTIS HC A04/MF A01 CSCL 01E

This report describes a 4-year work unit on the selection, development, and testing of a novel airfield marking system on ceramic-coated aluminized steel (CAS) tiles. The CAS tiles were developed to replace painted center marking lines that are obliterated by rubber streaks from jet tires from landing aircraft. The tiles are recessed or set into the pavement by grinding out 50- by 30-foot sections (1/8 inch deep) and bonding the tiles with epoxy/polyamide adhesive (2,000- to 5,000-psi tensile strength). The tiles can be easily cleaned by spraying with aqueous detergent and wiping off the rubber residue. The tiles are flexible, weather-resistant, chemically resistant, and highly reflective in day or evening, without retroreflective glass spheres. At $2.00 to $5.00 sq. ft., the CAS tiles are much more expensive than Federal Specification TT-P-1952 latex paint (about $0.10 sq. ft.), but the high initial cost can be offset in 1 year by lower maintenance costs. Although these CAS tiles are still being tested for Air Force use, the life cycle might be 5 to 10 years before replacement. GRA

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## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-13386**
**ESTIMATION OF THE FLUCTUATION AMPLITUDE OF THE ANGLE OF ATTACK OF A FLIGHT VEHICLE WITH NONLINEAR DAMPING CHARACTERISTICS IN THE PRESENCE OF ATMOSPHERIC TURBULENCE [OTSENKA AMPLITUDY KOLEBANII UGLA ATAKI LETATEL'NOGO APPARATA S NELINEINYMI KHARAKTERISTIKAMI DEMPFIROVANIIA PRI NALICHII ATMOSFERNOI TURBULENTNOSTI]**
A. S. NEMYKIN and V. A. IAROSHEVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 85-98. In Russian. refs

The plane motion of a flight vehicle with nonlinear damping characteristics relative to its center of mass is analyzed. For the amplitude-phase variables, equations of motion are written using the Van der Pol transformation. The corresponding Fokker-Planck-Kholmogorov equations are averaged in phase, which makes it possible to determine the steady-state amplitude distribution and to solve the problem of the probability of the threshold amplitude being exceeded. Approximate analytical formulas are presented, and the results are compared with the numerical calculations. V.L.

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## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-12761**
**FRACTURE TOUGHNESS CHARACTERIZATION OF LIGHT ALLOYS FOR AERONAUTICAL USE**
G. P. CAMMAROTA, G. GARAGNANI, P. BARIANI (Bologna, Universita, Italy), M. CIPRANDI, G. DONZELLI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Laboratorio Tecnologie Sperimentali, Gallarate, Italy) et al. International Journal of Fracture (ISSN 0376-9429), vol. 29, Sept. 1985, p. 47-55. refs

The fracture resistance properties of a rod and a plate, both made of 2024 aluminum alloy, are evaluated according to standard and non-standard methods. The materials are tested after heat treatments involving material microstructures different especially as to size and dispersion of the hardening precipitates. The sensitivity of various fracture-toughness parameters to microstructure conditions, specimen geometry, as well as their interactions is analyzed. Correlations established between standard and non-standard parameters confirm that alternative testing procedures are adequate to evaluate the fracture toughness of this alloy. Author

**A86-12925*** California Univ., Berkeley.
**DYNAMIC FEATURES OF COMBUSTION**
A. K. OPPENHEIM (California, University; California, University, Lawrence Berkeley Laboratory, Berkeley) Royal Society (London) Philosophical Transactions, Series A (ISSN 0080-4614), vol. 315, no. 1534, Sept. 26, 1985, p. 471-508. refs
(Contract DE-AC03-76SF-00098; NSF CPE-83-02232; NAG3-131; NAG3-137)

The dynamic features of combustion are discussed for four important cases: ignition, inflammation, explosion, and detonation. Ignition, the initiation of a self-sustained exothermic process, is considered in the simplest case of a closed thermodynamic system and its stochastic distribution. Inflammation, the initiation and propagation of self-sustained flames, is presented for turbulent flow. Explosion, the dynamic effects caused by the deposition of exothermic energy in a compressible medium, is illustrated by self-similar blast waves with energy deposition at the front and the adiabatic non-self-similar wave. Detonation, the most comprehensive illustration of all the dynamic effects of combustion, is discussed with a phenomenological account of the development and structure of the wave. C.D.

**A86-12989**
**ATOM-PROBE MICROANALYSIS OF A NICKEL-BASE SUPERALLOY**
D. BLAVETTE, A. BOSTEL, and J. M. SARRAU (Rouen-Haute Normandie, Universite, Mont-Saint-Aignan, France) Metallurgical Transactions A - Physical Metallurgy and Materials Science (ISSN 0360-2133), vol. 16A, Oct. 1985, p. 1703-1711. refs

A field ion microscope (FIM) atom-probe has been used to investigate the phase compositions in a Nb-Mo bearing nickel-based superalloy. The composition of gamma-prime precipitates in fully heat-treated conditions was found to vary with their mean sizes. The matrix analyses revealed the presence of fine secondary precipitates (30 to 100 A) which occupy 10 percent of the overall volume of the material. The high spatial resolution of the atom-probe allowed the gamma-gamma-prime interface characterization. Composition profiles show that the transition between the phases occurs within one interplanar spacing. Finally, a long range order study of the ordered gamma-prime phase has been performed. The analysis of the L1(2) type (Ni, X)3 (Al, Y) precipitates, made on an atomic plane-by-plane basis, shows how alloying elements substitute for Ni and Al in the gamma-prime sublattice. The observed results, expressed in terms of occupancy probabilities for both types of sites, indicate that Ti, Nb, and Mo preferentially occupy Al sites while Cr and Co substitute for Ni. Author

**A86-13005**
**PROTECTING GAS TURBINE COMPONENTS - THE RELATIVE DURABILITY OF A CONVENTIONAL AND A PLATINUM-MODIFIED ALUMINIDE COATING**
J. L. COCKING, G. R. JOHNSTON, and P. G. RICHARDS (Department of Defence, Materials Research Laboratories, Maribyrnong, Australia) Materials and Design (ISSN 0261-3069), vol. 6, Oct.-Nov. 1985, p. 224-229. refs

Platinum-modified aluminide coating for high pressure turbine blades and vanes was investigated by the Australian DOD. Conventional aluminide coating degradation research showed that the platinum-modified aluminide is superior. After 750 hours of operation, marked corrosive attack of the leading edge of the blades and concave side of the airfoil and corrosion pits along the center of the concave side were evident in the conventional aluminide coated engine. The 750 hours of operation of the platinum-modified aluminide coated engine retained 50 percent of the coating thickness in the areas of greatest attack such as the leading edge blades and the concave side; however, wide shallow pits occurred in the concave mid-chord region. Therefore, it was determined that platinum-modified aluminide coated blades are fit for re-use after 750 hours and even at full overhaul of 1000 hours of operation. F.J.

**A86-13076**

**NATIONAL SAMPE SYMPOSIUM AND EXHIBITION, 30TH, ANAHEIM, CA, MARCH 19-21, 1985, PROCEEDINGS**

Symposium and Exhibition sponsored by the Society for the Advancement of Material and Process Engineering. Covina, CA, Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 30), 1985, 1698 p. For individual items see A86-13077 to A86-13093, A86-13095 to A86-13102, A86-13104 to A86-13157, A86-13159 to A86-13164, A86-13166 to A86-13181.

Among the topics discussed are novel biomedical materials, high temperature polyimides, structures and materials for space structures, pressure sensitive adhesives, materials for advanced electronics, fiber/matrix-interface technologies, composite materials' testing and analysis techniques, thermoplastic matrices, recent advancements in automated and robotic manufacturing methods, and novel polymeric materials. Also covered are surface mount assembly technology, metallic materials for automated and robotic systems, novel matrix resin technologies, surface preparation and adhesive bonding methods, spacecraft and missile material design, the application of computers to materials engineering, advancements in filament winding techniques, advanced composites' design and manufacture, and environmental management. O.C.

**A86-13082**

**A LOW TEMPERATURE CURING, QUICK REPAIR, FUEL RESISTANT AIRCRAFT SEALANT**

L. MORRIS (Products Research and Chemical Corp., Glendale, CA) and C. NADLER (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 102-110.

The application times and cure rates of two commercial rapid curing Thiokol polysulfide based sealants of MIL-S-8802 and MIL-S-83318 (USAF) types are compared with the results observed with mercaptan terminated polythioether based sealants cured with epoxy resins. A tentative specification requiring more rapid low temperature conversions, MIL-S-85420 (AS), was used as the performance standard. The application and aging characteristics of the products equal or exceed the standards. A long application life, quick curing polythioether is also compared with current MIL-S-8802 qualified material and found to have advantages. Author

**A86-13101**

**ADHESIVE SYSTEM FOR HIGH TEMPERATURE DESTRUCTIVE TESTING OF COMPOSITE STRUCTURES**

C. M. GOOLSBAY (Vought Corp., Aero Products Div., Dallas, TX) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 399-405.

An adhesive test program has been conducted in order to develop an adhesive rubber tension pad system that would retain acceptable mechanical properties in a 400 F environment, such as that of the Navy S-3A aircraft's engine nacelle door. Mosite 14124 silicone rubber and 14206 film adhesive proved to be a system with performance far exceeding engine nacelle door test requirements. O.C.

**A86-13103**

**COMPOSITE REPAIRS**

H. BROWN, ED. (Society for the Advancement of Materials and Process Engineering, Azusa, CA) Covina, CA, Society for the Advancement of Materials and Process Engineering (SAMPE Monograph, No. 1), 1985. 232 p. No individual items are abstracted in this volume.

A comprehensive account is given of the advanced laminate composite repair methods that have been developed to date in the aerospace field, largely for fiber-reinforced polymer matrix composite aircraft primary structures. Attention is given to repair procedures for commercial transport aircraft graphite/epoxy structures, the acoustoultrasonic evaluation of impact-damaged graphite/epoxy, field level equipment for repair operations, depot level repair techniques, and intermediate/high temperature composite repair methods. Also discussed are the specialized methodologies for thermoplastic matrix composites and boron/epoxy composites, the repair of a stability-critical structure, and the effect of manufacturing defects on the strength of aircraft composite structures. O.C.

**A86-13118**

**CONFORMAL COATING FOR SURFACE MOUNT ASSEMBLY**

R. W. MALARIK (Lear Siegler, Inc., Instrument Div., Grand Rapids, MI) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 755-759.

Conformal coating of electronic assemblies with surface mounted devices represents a unique problem particularly related to the close spacing between the device and the board surface. Paraxylylene, a logical-choice, proved not to be satisfactory with a ceramic substrate. An acrylic resin was selected and a process established which satisfactorily sealed the device from the environment. Author

**A86-13170**

**ELECTRICALLY CONDUCTIVE STRUCTURAL ADHESIVE**

M. G. BILLIAS and M. E. BORDERS (Lockheed-Georgia Co., Marietta, GA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1397-1407.

The electrically conductive structural adhesive developed for the C-5A military cargo aircraft can sustain the high currents of lightning strike without bond failure, and has passed all requirements of MIL-B-5087(B) in simulated lightning strike tests. It is now being used to bond static dischargers to the extremities of the C-5B variant. The adhesive incorporates aluminum particles in place of the previously employed silver, eliminating the galvanic corrosion potential that had been established with the aircraft structure. The static dischargers also withstand lightning strike currents. MIL-S-9129(B) is also successfully passed. O.C.

**A86-13172**

**AIRCRAFT FIELD REPAIR**

D. J. ZALUCHA (Lord Corp., Industrial Adhesives Div., Erie, PA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1419-1423.

One approach to field repair of aircraft structures is the use of low energy cure adhesives to either bond patches and doubler plates in place or to serve as matrices for the fabrication of in situ composites. Advances in adhesive chemistry have in recent years led to the formulation of both epoxy and acrylic adhesives suitable for such field repairs, which can be conveniently packaged as kits for that purpose. While the epoxy systems can be cured with portable induction heaters, the acrylic ones may in addition take the form of two-element systems that can cure rapidly without additional energy input. O.C.

**A86-13174**

**CONSTANT TEMPERATURE HEATERS FOR THE REPAIR OF COMPOSITE STRUCTURES**

R. J. WALTY (Deposition Technology, Inc., San Diego, CA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1441-1451.

The self-regulating heaters that have been developed to facilitate field repairs of composite aircraft structures heat to a specific temperature which is required by the resin system in question and permit careful temperature control over large areas, using unregulated ac and dc power supplies. Tests have confirmed the superiority of these heaters to the constant wattage heaters currently in use, in light of thermal contour heat distribution analyses of both types of systems. O.C.

**A86-14474#**
**METALS ANAD PLASTICS - STATE OF THE ART AND PERSPECTIVES [METAUX ET PLASTIQUES - ETAT ACTUEL ET PERSPECTIVES]**
J. BRANDT, H. KELLERER, and P. WINKLER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) Association Aeronautique et Astronautique de France, Journee des Pionniers Europeens, Paris, France, Apr. 25, 1985, Paper. 35 p. In French.
(MBB-Z-49-85-OE)

Progress and expected advances in metals and plastics for aerospace usage, especially aircraft primary structures, are discussed. Metals, mostly Al and Ti alloys, are still the preferred materials, and are expected to be enhanced to have lower densities and display greater fracture resistance in the future. The advances will be achieved with new additives to the alloys, powder metallurgy, and superplastic forming. Metal matrix composites are also under investigation, as are fiber-reinforced plastics (FRPs), the latter being more developed and cheaper to produce than the metal counterparts. Kevlar and carbon fiber reinforcements are the most promising reinforcements; however, matrix materials have yet to reach reliability levels which would permit flight-certification of FRPs for primary structures. M.S.K.

**A86-14566#**
**COMBUSTION RELATED TO SOLID-FUEL RAMJETS**
B. N. RAGHUNANDAN, A. G. MARATHE (Indian Institute of Science, Bangalore, India), and E. R. RAVICHANDRAN Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 502-504. refs

Experiments conducted on a solid fuel ramjet-configuration apparatus have indicated that, at low inlet air temperatures, smoother ignition and sustained combustion are achievable through the dispersion of a small percentage of a solid oxidizer in the fuel matrix. Both the pressure index and the regression rate dependence on the transfer number encourage further examination and exploitation of this mode of combustion. O.C.

**A86-15220*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**CHARACTERIZATION OF THE THERMAL CONDUCTIVITY FOR FIBROUS REFRACTORY COMPOSITE INSULATIONS**
D. A. STEWART and D. B. LEISER (NASA, Ames Research Center, Moffett Field, CA) Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 6, July-Aug. 1985, p. 769-792. refs

Thermal conductivity for a family of fibrous, refractory composite insulations are characterized through the use of an engineering model and arc-jet data. The model defines the composite as a uniform pore material using measured physical and mechanical properties. Efficiency parameters assigned to the solid and radiation conduction terms in the thermal conductivity equation were found to be dependent only on solid volume fraction and porosity. Author

**A86-16100**
**MEASUREMENT OF PREFERENTIAL MOISTURE INGRESS IN COMPOSITE WING/SPAR JOINTS**
J. B. WHITESIDE, R. J. DELASI, and R. L. SCHULTE (Grumman Corporate Research Center, Bethpage, NY) (International Symposium on Composites: Materials and Engineering, University of Delaware, Newark, Sept. 24-28, 1984) Composites Science and Technology (ISSN 0266-3538), vol. 24, no. 2, 1985, p. 123-145. Research supported by Grumman Aerospace Corp. refs
(Contract F33615-78-C-3209)

The distribution of absorbed moisture was measured in three integral composite skin-to-spar joint concepts. The graphite/epoxy joint specimens were dried, exposed to heavy water vapor environment and sectioned. The method of nuclear reaction analysis was used to measure the distribution of absorbed moisture in the sectioned specimens. Two of the joint concepts had periodic fibrous reinforcement penetrating the skin: Kevlar stitches in one case and graphite tows in the other. In both cases the interior moisture concentrations in and around these stitches and tows were increased considerably above the corresponding interior moisture concentrations in areas remote from the stitches or tows. Measurements of absorbed moisture across the remote sections showed good agreement with Fickian diffusion distributions. The increased interior moisture level around the stitches is consistent with an interlaminar failure obtained in a previous hot-wet skin-spar shear test. Author

**N86-12259*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**EFFECT OF MEASURED MATERIAL PROPERTIES ON THE FINITE ELEMENT ANALYSIS OF AN OH-58 COMPOSITE TAIL BOOM**
L. M. BOWMAN Oct. 1985 28 p refs
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-86430; L-15969; NAS 1.15:86430; AVSCOM-TR-85-B-5) Avail: NTIS HC A03/MF A01 CSCL 11D

A static and dynamic finite element analysis is conducted on a U.S. Army OH-58 composite tail boom and compared with test data. The tail boom is a filament-wound graphite/epoxy monocoque structure. The structural design of the composite tail boom skin is based on 50-percent graphite fiber volume. However, material tests on representative samples of the tail boom skin reveal that the graphite fiber-volume fraction varied from 44.6 to 49.3 percent. To determine the effect of using measured material properties, static and dynamic finite element analyses are conducted for three fiber-volume conditions of 45, 48, and 50 percent. The static and dynamic model with the 45-percent fiber-volume graphite skins gives the closest agreement with test data. Author

**N86-12271#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**EXPERIMENTAL STUDY OF THE COMBUSTION OF GAS-AIR MIXTURES IN A CHANNEL AND THE DIFFUSION COMBUSTION IN A SLIPSTREAM AT HIGH VELOCITIES**
V. K. BAYEV, P. K. TRETYAKOV, and V. A. YASAKOV 16 Jul. 1985 49 p Transl. into ENGLISH from mono. "Sovremennoye Sostoyaniye i Teoriya Sgoraniya Kondensirovannykh Sistem" Moscow, 1972 p 357-360, 386-391, 416-420, 421-425
(AD-A157495; FTD-ID(RS)T-1323-84) Avail: NTIS HC A03/MF A01 CSCL 21B

This translation contains three additional papers by other authors. Their titles are: Ignition and Interruption of Combustion in the Stagnation Zone During Flow Around a Flatstep or Indentation by a Supersonic Flow of Combustible Mixture; Combustion of Rich Kerosine-Air Mixture in Tunnel Type Chamber; and Mechanism of the Process of Combustion After the Front Devices and in the Zone of the inflow of the Jets of Secondary Air in the Chambers of Gas-Turbine Engine. GRA

**N86-12272#** Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
**METHOD TO DETECT ETHYLENE GLYCOL IN GASEOUS MIXTURES Final Report, 1 Oct. 1982 - 30 Sep. 1983**
R. E. WILLIS Aug. 1985 53 p Prepared in cooperation with Sverdrup Technology, Inc., Arnold AFS, TN
(AD-A158109; AEDC-TR-85-39) Avail: NTIS HC A04/MF A01 CSCL 07D

Ethylene glycol is used as a refrigerant for the intake air during simulated altitude testing. There have been some problems during these tests because of the ethylene glycol accidentally leaking into the inlet airstream. Since ethylene glycol has at times been suspected of interfering with the test article, its early detection would be greatly beneficial so that testing could be stopped before damage occurs. Because a detection scheme must indicate the presence of ethylene glycol as soon as it appears in the inlet airstream, a spectroscopic technique is preferred over other methods of gas analysis such as sampling and subsequent laboratory analysis. A study was conducted to determine if microwave spectroscopy techniques could be used to monitor the level of ethylene glycol in the inlet airstream to the Engine Test Facility (ETF) test cells during simulated altitude testing. The theory of microwave spectroscopy and the spectra of ethylene glycol are reviewed. Three separate designs of microwave spectrometers are presented which should be capable of monitoring ethylene glycol in the inlet airstreams with a sensitivity of at least 10 ppm. GRA

**N86-13407*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**POLYMER, METAL AND CERAMIC MATRIX COMPOSITES FOR ADVANCED AIRCRAFT ENGINE APPLICATIONS**
D. L. MCDANELS, T. T. SERAFINI, and J. A. DICARLO 1985 26 p refs Presented at the Advanced Composites Conference, Detroit, 3-4 Dec. 1985; sponsored by ASME
(NASA-TM-87132; E-2746; NAS 1.15:87132) Avail: NTIS HC A03/MF A01 CSCL 11F

Advanced aircraft engine research within NASA Lewis is being focused on propulsion systems for subsonic, supersonic, and hypersonic aircraft. Each of these flight regimes requires different types of engines, but all require advanced materials to meet their goals of performance, thrust-to-weight ratio, and fuel efficiency. The high strength/weight and stiffness/weight properties of resin, metal, and ceramic matrix composites will play an increasingly key role in meeting these performance requirements. At NASA Lewis, research is ongoing to apply graphite/polyimide composites to engine components and to develop polymer matrices with higher operating temperature capabilities. Metal matrix composites, using magnesium, aluminum, titanium, and superalloy matrices, are being developed for application to static and rotating engine components, as well as for space applications, over a broad temperature range. Ceramic matrix composites are also being examined to increase the toughness and reliability of ceramics for application to high-temperature engine structures and components. Author

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# ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-13011**
**METHODS OF CONSTRUCTING R-CURVES AND APPLICATION OF THESE CURVES FOR EVALUATION OF MATERIALS (REVIEW)**
G. S. NESHPOR, G. D. KUDRIAVTSEVA, and A. A. ARMIAGOV (Zavodskaia Laboratoriia, vol. 51, Jan. 1985, p. 64-73) Industrial Laboratory (ISSN 0019-8447), vol. 51, no. 1, July 1985, p. 74-85. Translation. refs

The theoretical background and methods for deriving the R-curve, i.e., the resistance of a material to stable crack growth, is reviewed, along with techniques for applying it to test materials. The R-curve is based on the assumption that the energy released during unstable crack growth is constant, although in some wide specimens plastic deformation at the crack tip will cause the rate of energy release to vary from that expected. The R-curve values are a function of the stress and the effective crack length. The stress value is determined for materials by tensile testing a center-cracked flat specimen, a side-cracked compact specimen and a specimen undergoing wedge loading along the crack line to derive load-displacement data. Sample calculations are carried out for sheets of a steel alloy. M.S.K.

**A86-13059*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**HIGH-TEMPERATURE THERMOCOUPLE AND HEAT FLUX GAUGE USING A UNIQUE THIN FILM-HARDWARE HOT JUNCTION**
C. H. LIEBERT, R. HOLANDA, S. A. HIPPENSTEELE, and C. A. ANDRACCHIO (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 938-944. Previously announced in STAR as N85-16096. refs
(ASME PAPER 85-GT-18)

A special thin film-hardware material thermocouple (TC) and heat flux gauge concept for a reasonably high temperature and high flux flat plate heat transfer experiment was fabricated and tested to gauge temperatures of 911 K. This concept was developed for minimal disturbance of boundary layer temperature and flow over the plates and minimal disturbance of heat flux through the plates. Comparison of special heat flux gauge Stanton number output at steady-state conditions with benchmark literature data was good and agreement was within a calculated uncertainty of the measurement system. Also, good agreement of special TC and standard TC outputs was obtained and the results are encouraging. Oxidation of thin film thermoelements was a primary failure mode after about 5 of operation. Author

**A86-13061*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**LOCAL HEAT-TRANSFER MEASUREMENTS ON A LARGE SCALE-MODEL TURBINE BLADE AIRFOIL USING A COMPOSITE OF A HEATER ELEMENT AND LIQUID CRYSTALS**
S. A. HIPPENSTEELE, L. M. RUSSELL, and F. J. TORRES (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 107, Oct. 1985, p. 953-960. Previously announced in STAR as N85-33435. refs
(ASME PAPER 85-GT-59)

Local heat transfer coefficients were experimentally mapped along the midchord of a five-time-size turbine blade airfoil in a static cascade operated at room temperature over a range of Reynolds numbers. The test surface consisted of a composite of commercially available materials: a mylar sheet with a layer of cholesteric liquid crystals, that change color with temperature, and a heater sheet made of a carbon-impregnated paper, that produces uniform heat flux. After the initial selection and calibration of the composite sheet, accurate, quantitative, and continuous heat transfer coefficients were mapped over the airfoil surface. The local heat transfer coefficients are presented for Reynolds numbers from 2.8 x 10 to the 5th power to 7.6 x 10 to the 5th power. Comparisons are made with analytical values of heat transfer coefficients obtained from the STANS boundary layer code. Also, a leading edge separation bubble was revealed by thermal and flow visualization. Author

**A86-13111**
**F/A 18 COMPOSITE WING AUTOMATED DRILLING SYSTEM**
E. L. BOHANAN, JR. (McDonnell Aircraft Co., St. Louis, MO) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 579-585.

The key factors influencing the configuration and subsystems of the F/A-18 aircraft wing assembly Automated Drilling System (ADS) were the wide variety of fastener hole sizes generated in the composite/metallic material and the improved machining control parameters demanded by these advanced materials. Better cutters and more precise spindles than had been available with pneumatic drilling motors were also called for. ADS production implementation has furnished a cost-effective way of meeting present requirements without resort to hard tooling concepts. O.C.

**A86-13135**

### AGE CREEP FORMING IN AN AUTOCLAVE

D. M. HAMBRICK (Avco Corp., Avco Aerostructure Div., Nashville, TN) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 971-981.

Development of the autoclave forming aluminum process has advanced current technology of age forming. Using an autoclave for application of aging heat and forming pressure, the process has been used to form 50 feet long, 2124 and 2419 aluminum wing skins containing integrally machined stiffeners and varying in thickness from 0.1 to 2.5 inches with thick pads in the middle of thin sections. The process produces smooth contours with no visible signs of abrupt changes in thickness. The skins are believed to be the largest and most complex parts ever to be age creep formed in the history of the aircraft industry. Author

**A86-13147**

### NONDESTRUCTIVE TEST METHODS FOR COMPOSITE STRUCTURES

K. L. REIFSNIDER (Virginia Polytechnic Institute and State University, Blacksburg) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1131-1142. refs

A comparative assessment is made among the three available structural NDT&E methods that are currently available for the response characteristics of missile airframe and space structure assemblies. In vibrothermography, a carefully chosen frequency is used to excite specific structural defects until a heat-pattern of dissipated energy is formed for imaging; structural discontinuities are thereby revealed. Stiffness changes can reflect material integrity and mechanical (especially vibratory) response. C-scan and acoustoultrasonic methods constitute the third family of methods considered. O.C.

**A86-13171**

### PREDICTION AND MEASUREMENT OF DAMPING OF VIBRATIONS OF STRUCTURES BY ADHESIVES

R. A. ELY and K. B. SANGHA (LTV Aerospace and Defense Co., Dallas, TX) IN: National SAMPE Symposium and Exhibition, 30th Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1408-1418. refs

Attention is given to a method for the mathematical selection of adhesives to yield large vibration damping levels in structures, with emphasis on the major influences exerted by ambient temperature and mechanical excitation frequency on the selection of such adhesive damping treatments. In addition to laboratory tests and computer calculations aiding the development of adhesively damped components for aircraft structures, two examples of fighter aircraft components employing constrained adhesive layers are presented: a flap and a spoiler, which were chronically subject to pressure fluctuations. O.C.

**A86-13180**

### BOEING MILITARY AIRPLANE COMPANY'S ROBOTIC ULTRASONIC INSPECTION SYSTEM

B. W. VON ASPE, K. C. STEWART, and K. E. GRAEBNER (Boeing Military Airplane Co., Wichita, KS) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1655-1664.

Attention is given to a proprietary robotic system for the ultrasonic inspection of composite structures with compound curvatures which rapidly follows these contours while maintaining the geometric normality of the ultrasonic sensors to the surface of the structure. Since the robot must know the contours well, a digitizing scan is initially performed to determine and store structural shapes. The systems inspects the structure for internal voids, delaminations and unbounds. O.C.

**A86-13221**

### A MICROPROCESSOR-BASED DIGITAL VOICE NETWORK

J. MOSES and R. SKLAR (Hughes Aircraft Co., Microelectronic Systems Div., Irvine, CA) IN: ITC/USA/'84; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 22-25, 1984 . Research Triangle Park, NC, Instrument Society of America, 1984, p. 299-306.

An internal research and development program is described that is intended to advance the state of the art in digital voice technology and demonstrate digital voice transmission using advanced microprocessor technology and token-passing bus network architecture. The design architecture, terminal design and implementation, and future plans to satisfy digital voice requirements in a military environment are examined. D.H.

**A86-13336#**

### NEW METHODS OF MEASURING STRAIN AND TEMPERATURE IN A TURBINE ENGINE

W. A. STANGE (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: International Congress on Experimental Mechanics, 5th, Montreal, Canada, June 10-15, 1984, Proceedings . Brookfield Center, CT, SESA, 1984, p. 565-570.

This paper presents an overview of current research efforts aimed at improving turbine engine structural instrumentation capabilities. Emphasis is placed on high temperature applications and improved sensor reliability. Technologies to be described include blade tip deflection sensors to determine dynamic stress, acoustic guided wave sensors to measure steady state strain, and double core fiber optics to measure both metal temperature and steady state strain. Advantages of the various systems, potential problems and limitations, as well as an assessment as to when the various technologies are likely to be ready for actual engine test usage are presented. Author

**A86-13338#**

### EXPERIMENTAL/ANALYTIC COMPARISONS CONSIDERING COMPOSITE PANELS WITH A CUTOUT

A. N. PALAZOTTO, M. SABOTA (USAF, Institute of Technology, Wright-Patterson AFB, OH), and T. JANISSE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Congress on Experimental Mechanics, 5th, Montreal, Canada, June 10-15, 1984, Proceedings . Brookfield Center, CT, SESA, 1984, p. 628-633.

The nonlinear finite element (STAGSC-1) program was used to calculate the values of radial displacement (RD) in a composite graphite/epoxy panel with a symmetrically positioned square cutout that is subjected to buckling loads of 2000, 2500, and 3300 lb. These RD values were compared with experimental measurements obtained under the defined conditions. The comparison shows the sensitivity of the panel to varying boundary conditions produced by the restraints associated with the experimental panel. A description of the techniques used for fabrication of composite cylindrical panels and application of the compressive load, and of the boundary conditions, as well as the STAGSC computer code, is included. I.S.

**A86-13342#**

### APPLICATION OF COMPUTERIZED DATA ACQUISITION AND DATA PROCESSING TO THE SURFACE CONTOURING OF LARGE STRUCTURES

T. M. MILLY and A. HUNTER (Lockheed Research Laboratories, Palo Alto, CA) IN: International Congress on Experimental Mechanics, 5th, Montreal, Canada, June 10-15, 1984, Proceedings . Brookfield Center, CT, SESA, 1984, p. 795-799.

This paper deals with techniques and procedures for contouring relatively large surfaces using shadow and projection moire. The Experimental Strain Analysis Processing System (ESAPS), developed at LMSC, is then applied to these techniques to increase speed and efficiency of processing. In addition, the capability has been developed which provides for the examination of the overall contours of large areas as well as detailed localized contours. With systematically obtained contour data, interactive processing procedures provide for correlation analysis and accurate interpretation of incoming data. Author

**A86-13357**

### PANEL DESIGN FOR OPTIMUM STRENGTH AND STABILITY WITH ALLOWANCE FOR THE NONUNIFORMITY OF HEATING [PROEKTIROVANIE PANELEI PO USLOVIIAM PROCHNOSTI I USTOICHIVOSTI S UCHETOM NERAVNOMERNOGO NAGREVA]

G. P. GROSHEV and E. K. LIPIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 95-103. In Russian.

The problem of optimizing the design of a reinforced panel with respect to strength and stability is solved with allowance for the interaction of the panel with the flanges of the spars and wing ribs under conditions of nonuniform heating. It is shown that in the case of high total compressive forces in the root section of the wing, sections with heavy spar flanges can be used without a significant increase in weight in comparison with the wing sections having thermocompensated panels. V.L.

**A86-13362**

### AN ALGORITHM FOR CALCULATING THE COUPLING BETWEEN MATRICES OF ELASTIC INFLUENCE COEFFICIENTS FOR TWO SYSTEMS OF COMPUTATIONAL POINTS [ALGORITHM VYCHISLENIIA SVIAZI MATRITS UPRUGIKH KOEFFITSIENTOV VLIIANIIA V DVUKH RASCHETNYKH SISTEMAKH TOCHEK]

S. V. EFIMENKO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 1, 1984, p. 133-136. In Russian.

The interpolation of a function of two variables by spline surfaces is used to calculate the elastic influence coefficients in a system of computational points on an elastic surface from the influence coefficients of a different system of points. To illustrate the approach proposed here, calculations are carried out for a cantilever plate. V.L.

**A86-13367**

### CONSIDERATION OF THE MULTIPLICITY OF CRITICAL SPOTS IN A STRUCTURE IN ESTIMATING THE DURABILITY AND THE SERVICE LIFE [UCHET MNOZHESTVENNOSTI KRITICHESKIKH MEST KONSTRUKTSII PRI OTSENKE GOLGOVECHNOSTI I RESURSA]

V. L. RAIKHER, A. F. SELIKHOV, and I. G. KHLEBNIKOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 2, 1984, p. 72-81. In Russian. refs

An aircraft structure is treated as a system containing a large number of individual elements (stress raisers), and it is shown that, under certain assumptions, this approach makes it possible to obtain a statistical model for the service life of a structure. Such a model is proposed here for the case where the durabilities of individual elements can be considered to be independent and for the case where the individual durabilities are related in a certain manner. The validity of this approach is verified experimentally using several examples. The possible versions of the durability distribution function of an individual component are examined. V.L.

**A86-13382**

### AN EXPERIMENTAL STUDY OF A VACUUM WATER-AIR EJECTOR WITH A MULTICHANNEL LIQUID-SUPPLY NOZZLE ENSURING JET-PAIR COLLISION [EKSPERIMENTAL'NOE ISSLEDOVANIE VAKUUMNOGO VODOVOZDUSHNOGO EZHEKTORA S MNOGOSTVOL'NYM SOPLOM DLIA PODACHI ZHIDKOSTI, OBESPECHIVAIUSHCHIM POPARNOE SOUDARENIE STRUI]

IU. N. VASILEV, E. P. GLADKOV, and G. A. GORSHKOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 45-54. In Russian.

Experimental results are reported for a vacuum water-air ejector with a cylindrical mixing chamber and a multichannel water-supply nozzle in which the axes of the adjacent channels are inclined relative to each other at a small angle, resulting in pair collisions of the jets in the mixing chamber and a more intense jet fractionation. A comparison with results obtained for an ejector using a water-supply nozzle with parallel channels shows that the collision of jets significantly increases the efficiency of the ejector. V.L.

**A86-13387**

### A PROPERTY OF THE ELASTIC VIBRATIONS OF NEARLY SYMMETRIC SYSTEMS [OB ODNOI OSOBENNOSTI UPRUGIKH KOLEBANII 'POCHTI SIMMETRICHNYKH' SISTEM]

IA. M. PARKHOMOVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 99-106. In Russian.

It is shown that a slight asymmetry of the mass and stiffness characteristics of an aircraft relative to a vertical plane intersecting the longitudinal axis of the aircraft can sometimes cause essentially asymmetric vibrational modes. In particulaiar, this is true of the torsional modes of the wings. The mechanism of this phenemenon is illustrated by a model problem. V.L.

**A86-13388**

### A MODEL FOR THE LIFE VARIANCE OF A STRUCTURAL ELEMENT UNDER IRREGULAR LOADING [MODEL' RASSEIANIIA DOLGOVECHNOSTI ELEMENTA KONSTRUKTSII PRI NEREGULIARNOM NAGRUZHENII]

A. F. SELIKHOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 3, 1984, p. 107-120. In Russian. refs

A life variance model developed in an earlier study (Selikhov, 1984) for regular loading is extended to the case of irregular loading. By using the formalism of individual fatigue damage curves for true stresses at the highest-load point, an expression for the life variance is obtained for the case where the relative cycle number based on nominal stresses is not equal to unity. The model proposed here explains certain characteristics of life variance under conditions of irregular loading. V.L.

**A86-13410**

### USING ISOPERIMETRIC INEQUALITIES FOR THE TWO-SIDED ESTIMATION OF THE TORSIONAL STIFFNESS OF A PRISMATIC BAR [PRIMENENIE IZOPERIMETRICHESKIKH NERAVENSTV DLIA DVUKHSTORONNEI OTSENKI ZHESTKOSTI KRUCHENIIA PRIZMATICHESKOGO STERZHNIA]

V. V. EGOROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 120-123. In Russian.

A formula is proposed which makes it possible to obtain the upper and lower bounds for the torsional stiffness of a prismatic bar from two geometrical parameters of its cross-section, the perimeter and the area. This formula can be used to determine the trend of the change of the cross-sectional torsional stiffness for any change in the shape of the cross-section (e.g., in the case of cross-section reinforcement or replacement of one cross-section by another). V.L.

**A86-13419**

### ALLOWANCE FOR INITIAL CONDITIONS IN STATIC AND DYNAMIC CALCULATIONS OF STRUCTURES BY THE FINITE ELEMENT METHOD [UCHET NACHAL'NYKH USILII V STATICHESKIKH I DINAMICHESKIKH RASCHETAKH KONSTRUKTSII METODOM KONECHNYKH ELEMENTOV]

V. P. AGAPOV, V. D. ILICHEV, V. A. KOROTKOV, and A. V. STRELIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 79-89. In Russian. refs

The influence of initial conditions on the stiffness characteristics of aircraft structures in static and dynamic calculations is examined. A method for including initial conditions in the finite element method is described, with particular attention given to a procedure for obtaining the initial-stress matrix for a plane triangular element. The accuracy of the method is illustrated by model problems, and calculation results for the natural vibrations of a propeller are compared with experimental data. B.J.

**A86-13424**
**CERTAIN PROBLEMS OF FLUID FLOW NEAR THE CORE OF A SPIRAL DISCONTINUITY [NEKOTORYE ZADACHI O TECHENII ZHIDKOSTI V OKRESTNOSTI IADRA SPIRAL'NOGO RAZRYVA]**
A. M. GAIFULLIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 125-131. In Russian. refs

The structure of the core of a vortex sheet is analyzed in flows that are only slightly different from self-similar ones; on a low-aspect-ratio delta wing this corresponds to a slight curvature of the vortex-sheet axis. Also investigated is the structure of the core of a vortex sheet and a free boundary in axisymmetric self-similar flows. A comparison is made with the two-dimensional case. B.J.

**A86-13430**
**SEPARATED FLOW PAST A SHARP EDGE ACCORDING TO A REVERSE-JET SCHEME [OTRYVNOE OBTEKANIE OSTROI KROMKI PO SKHEME S VOZVRATNOI STRUIKOI]**
L. A. KOZHURO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 6, 1984, p. 10-18. In Russian. refs

A solution is obtained to the problem of separated incompressible inviscid flow past a sharp edge according to Efros' scheme in the limiting case of an infinite velocity at the free streamline. The rate of change in reverse-jet momentum remains finite and is equal to the suction force acting on the sharp edge in the case of nonseparated flow. A finite concentrated force acts on the edge in a direction perpendicular to the action of the suction force. Attention is given to the limit state for flow past a plate at angle of attack with separation at the leading edge, when the velocity at the free streamline tends to infinity. B.J.

**A86-13463**
**CUTOUTS IN LOAD-BEARING STRUCTURES [VYREZY V NESUSHCHIKH KONSTRUKTSIIAKH]**
I. N. PREOBRAZHENSKII and I. A. TSURPAL Moscow, Izdatel'stvo Mashinostroenie, 1984, 112 p. In Russian. refs

Data are presented on the stability, natural frequencies, and stress distributions of the critical parts of machines and structural elements near holes, cavities, and other types of abrupt changes in the cross-section. The effect of various factors on stress concentration is estimated for different types of structures and materials. In particular, attention is given to the effect of reinforcing elements, the effect of material anisotropy, dynamic problems, the effect of the viscoelastic properties of materials on stress distribution near holes, and nonlinear problems of stress concentration. V.L.

**A86-13671**
**THE DRAG OF A THERMALLY INSULATED PLATE IN A STREAM OF A COMPRESSIBLE GAS UNDER MIXED FLOW CONDITIONS [SOPROTIVLENIE TEPLOIZOLIROVANNOI PLASTINY V SZHIMAEMOM POTOKE GAZA PRI SMESHANNOM OBTEKANII]**
L. F. KOZLOV (AN USSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 7, no. 4, 1985, p. 17-20. In Russian. refs

A formula is obtained for calculating the aerodynamic drag of a thermally insulated plate in a high-velocity compressible-gas stream with a mixed boundary layer. The formula proposed here allows for the finite length of the transition region and is reduced to the known solutions for the cases of a fully laminar and a fully turbulent boundary layer. V.L.

**A86-13673**
**THE EFFECT OF THE DEFLECTOR TYPE ON INTERNAL HEAT TRANSFER IN BLADES WITH TRANSVERSE COOLANT FLOW [VLIIANIE TIPA DEFLEKTORA NA VNUTRENNII TEPLOOBMEN V LOPATKAKH S POPERECHNYM TECHENIEM OKHLADITELIA]**
A. N. BOIKO, M. N. GALKIN, S. Z. KOPELEV, and I. V. SHEVCHENKO (Moskovskii Aviatsionnyi Tekhnologicheskii Institut, Moscow, USSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 7, no. 4, 1985, p. 42-46. In Russian.

The internal heat transfer characteristics of a deflector blade are determined by liquid-metal thermostat calorimetry. The coefficients of heat transfer to the cooling air are obtained for the mean blade cross-sectional area for three types of deflectors. It is found that in deflector plates with slots or round nozzles, the cooling intensity of the inlet edge is a factor of 1.6-1.9 higher than in blades with transverse cuts. V.L.

**A86-13690**
**DYNAMIC STRENGTH PROBLEMS IN AEROSPACE EQUIPMENT [O PROBLEMAKH DINAMICHESKOI PROCHNOSTI V AVIATSIONNO-KOSMICHESKOI TEKHNIKE]**
I. F. OBRAZTSOV Raschety na Prochnost', no. 25, 1984, p. 3-11. In Russian. refs

The paper is concerned with a wide range of problems arising during the manufacture and operation of the structural elements of aerospace equipment due to increased velocity, power, dimensions, and other flight vehicle parameters. Particular attention is given to the dynamic strength of structures, which in many cases determines the durability and performance of flight vehicle structures. Several dynamic strength problems are analyzed, aand some problems that have yet to be solved are mentioned. V.L.

**A86-13983**
**QUASI-SOLUTIONS OF AN INVERSE BOUNDARY VALUE PROBLEM OF HYDROAERODYNAMICS [KVAZIRESHENIIA OBRATNOI KRAEVOI ZADACHI GIDROAERODINAMIKI]**
A. M. ELIZAROV, N. B. ILINSKII, and A. V. POTASHEV (Kazanskii Gosudarstvennyi Universitet, Kazan, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 284, no. 2, 1985, p. 319-322. In Russian. refs

The following inverse boundary value problem is considered: to determine the form of a closed wing profile in the two-dimensional potential steady flow of an ideal incompressible fluid according to a specified velocity distribution on the profile surface. Examples of numerical calculations based on the method of quasi-solutions are given. B.J.

**A86-14157#**
**COMPUTATION OF AERONAUTICAL STRUCTURES [CALCULUL STRUCTURILOR DE AVIATIE]**
A. PETRE Bucharest, Editura Tehnica, 1984, 368 p. In Romanian. refs

The book presents both the classical and modern computational methods of aircraft structures. After a brief historical review of aviation, the general design and stress-strain problems are exposed. Aerodynamic principles, loads, shell structures, buckling, reliability, post-buckling behavior and plates and bars are covered in detail. A section on optimization problems ends the classical study. The modern section starts with the matrix methods, discusses the finite element method and concludes with a structural synthesis and optimization theory. The book is of interest to the academic world as well as to engineers and designers working in the aeronautical field. N.D.

**A86-14348**
**WEIGHT OPTIMIZATION OF STIFFENED CYLINDERS UNDER AXIAL COMPRESSION**
R. QIU Computers and Structures (ISSN 0045-7949), vol. 21, no. 5, 1985, p. 945-952. refs

A procedure is developed for the design of a stiffened cylinder under a given uniform axial compression with minimum weight. The approach allows the consideration of various shapes of stiffening members. The effective stiffness of the skin in its post-buckled state is taken into account in the basic analysis. The buckling analyses are accomplished as a minimum problem in the buckling mode shape parameters space using the variable metric method. A mixed procedure which combines the exterior penalty function concept and random search is used to minimize the weight of the stiffened cylinders. The design examples demonstrate the validity of the present approach. Author

**A86-14355#**
**'BUT NOT WITH THE GREATEST OF EASE' - A FEASIBILITY STUDY OF A HUMAN-POWERED ACV**
H. S. FOWLER (National Research Council of Canada, Ottawa) (Canadian Air Cushion Technology Society, International Conference on Air Cushion Technology, Vancouver, Canada, Sept. 26, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, June 1985, p. 107-115. refs

An assessment is made of the propulsion efficiency-related difficulties that are ineluctably encountered in attempts to design human-powered air cushion vehicles (ACVs). After defining an arbitrary human-powered ACV, a terrain representative of the kind that such a vehicle should be able to traverse is selected to evaluate the feasibility of the design within current engineering and human performance capabilities. An ACV capable of 1 hour of sustained operation over a flat, smooth course of approximately 10 km is foreseen. O.C.

**A86-14424**
**FORGING IN THE AEROSPACE INDUSTRY [LE FORGEAGE DANS L'INDUSTRIE AEROSPATIALE]**
N. BEAUCLAIR Air et Cosmos (ISSN 0044-6971), vol. 23, Oct. 19, 1985, p. 19-21, 23-27, 29. In French.

The recent recession slowed the rate at which foundaries could afford to invest in plant modernization. Modernization, i.e. CAD/CAM and net-shape forming of metals, is a necessity in order to control the costs of delivered products, which for aerospace applications usually require a high degree of precision in the stamping and forging processes. The new manufacturing techniques are currently applied in working with specialty steels, Ni, Ti and Al alloys, and will necessarily be extended to cover superalloys. Some relief is being experienced by the subcontractors due to the demand for the delivery of eight Airbus aircraft per month, along with a number of Mirage 2000 aircraft. Production of the Airbus has not, thus far, surpassed 4.5 per month. M.S.K.

**A86-14538#**
**PRODUCTIVITY IMPROVEMENTS THROUGH THE USE OF CAD/CAM**
M. D. WEHRMAN (Boeing Commercial Airplane Co., Seattle, WA) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1079-1084) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 1013-1017. Previously cited in issue 22, p. 3222, Accession no. A84-45048.

**A86-14539#**
**EVALUATION OF LOW REYNOLDS NUMBER TURBULENCE MODELS FOR ATTACHED AND SEPARATED FLOWS**
A. SUGAVANAM (Lockheed-Georgia Co., Marietta, GA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Nov. 1985, p. 1018-1020. Previously cited in issue 07, p. 898, Accession no. A85-19706. refs

**A86-14554#**
**COUNTERROTATING INTERSHAFT SEALS FOR ADVANCED ENGINES**
W. L. GAMBLE (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, Nov.-Dec. 1985, p. 437-440. Previously cited in issue 16, p. 2343, Accession no. A84-35135.

**A86-14680**
**THE PERFORMANCE OF COMPOSITE STRUCTURES [RABOTOSPOSOBNOST' KONSTRUKTSII IZ KOMPOZITSIONNYKH MATERIALOV]**
N. D. KUZNETSOV and N. D. STEPANENKO (Kuibyshevskii Aviatsionnyi Institut, Kuibyshev, USSR) Problemy Prochnosti (ISSN 0556-171X), Oct. 1985, p. 12-19. In Russian. refs

An approach to the design and development of a process for the manufacture of turbine blades of composite materials is presented which ensures the high performance of the blades. Particular attention is given to resonance methods for part and material quality control. With reference to test results obtained for a composite reinforced with glass and carbon fibers it is shown how the volume fraction of the reinforcement material affects the fatigue strength of the composite structure. V.L.

**A86-14973**
**PRECISION CASTING AT ROLLS-ROYCE**
R. J. SOUTHGATE Metals and Materials (ISSN 0266-7185), vol. 1, Oct. 1985, p. 602-604, 606.

A development history and status account is presented for near-net shape, high precision aircraft engine component casting methods employed by a major manufacturer of high bypass turbofans for commercial aircraft. The complexity of such components as gas turbine blades is so great that an elaborate assembly of small and fragile ceramic cores must be inserted in the pattern die before closure and wax injection. Molds used for single crystal or directionally solidified superalloy castings differ from conventional types in that openings must be provided for the fitting of a chill plate. Ceramic shell molding techniques are also used for high temperature engine components. Attention is given to the industrial apparatus, including process and quality control elements, that have been developed by the manufacturer. O.C.

**A86-15227*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**EXPERIMENTAL STUDY OF CERAMIC-COATED TIP SEALS FOR TURBOJET ENGINES**
T. J. BIESIADNY, G. MCDONALD, R. C. HENDRICKS (NASA, Lewis Research Center, Cleveland, OH), G. A. KLANN (U.S. Army, Propulsion Laboratory, Cleveland, OH), E. S. LASSOW (Howmet Turbine Components Corp., Whitehall, MI) et al. Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 6, July-Aug. 1985, p. 880-895. Previously announced in STAR as N85-19363. refs

Ceramic gas-path seals were fabricated and successfully operated over 1000 cycles from flight idle to maximum power in a small turboshaft engine. The seals were fabricated by plasma spraying zirconia over a NiCoCrAlX bond coat on the Haynes 25 substrate. Coolant-side substrate temperatures and related engine parameters were recorded. Post-test inspection revealed mudflat surface cracking with penetration to the ceramic bond-coat interface. Author

**A86-15528**
**PORTABLE COMPUTERIZED TESTER IMPROVES FLIGHT-LINE MAINTENANCE**
Y. GRINBERG (RADA Electronic Industries, Ltd., Herzliya and Beth Shean, Israel) Defense Electronics (ISSN 0278-3479), vol. 17, Nov. 1985, p. 67, 68, 70, 71.

The present general purpose and portable Computerized Organizational Level Tester (COLT) for the flight-line maintenance of advanced weapons systems is in effect a fully functioning replica of contemporary automated test equipment architectures previously available only in laboratory test installations. The COLT's automated equipment architecture has been scaled down to a ruggedized, portable, suitcase-sized field tester for both analog and digital equipment. Tester software is designed to minimize programming effort, and possesses a real time executive kernel which transparently interfaces high level user commands with tester hardware. Automatic software-generation tools are incorporated. O.C.

**A86-15584**

**OPTICAL COMMUNICATION BETWEEN AIRCRAFT IN LOW-VISIBILITY ATMOSPHERE USING DIODE LASERS**

A. K. MAJUMDAR (Lockheed-California Co., Kelly Johnson Research and Development Center, Burbank, CA) Applied Optics (ISSN 0003-6935), vol. 24, Nov. 1, 1985, p. 3659-3665. Research supported by the Lockheed-California Co. refs

The performance of an atmospheric optical communication link using multiple-forward-scattered (MFS) radiation is examined theoretically and experimentally. In particular, results of a laboratory-simulation experiment are used to estimate beam spread/angular spread angle in terms of channel coherence length, rms forward scatter angle, and forward-scattering efficiency, with a GaAlAs laser diode (0.8486 micron) used as a source. A pulse-position-modulation format is then considered, and the minimum field of view which optimizes the system margin for given data rate, low-visibility atmospheric parameter, and background condition is determined. The feasibility of acquisition and high-rate-data transfer between aircraft through low-visibility atmosphere is shown to be feasible. This can provide a relatively covert system with high immunity to jamming. V.L.

**A86-16032#**

**DYNAMIC RESPONSE OF A LAMINATED PLATE WITH FRICTION DAMPING**

S. Z. HAN (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 107, Oct. 1985, p. 375-377.
(ASME PAPER 85-DET-16)

A sandwich-type plate with metal facings and felt core, fastened by bolts, was studied using both test and finite-element analysis. This type of plate is cheap, light, damping-effective and without pollution; therefore, it is widely used in astronautical engineering. The tests were conducted for different felt thicknesses, bolt numbers, and fastening forces. The results show that the damping depends on friction between the plates and the felt. As compared with an identical stiffness solid plate, the damping of laminated plates can be increased up to 30 times. A mesh with rectangular elements was adopted in the finite-element analysis. In accordance with the slipping mechanism, a rectangular plate clamped on one edge was analyzed with the foregoing elements to determine the resonant frequency and the damping. The difference between the calculated and tested results was within 5 percent for the resonant frequency. Author

**A86-16040#**

**ROTOR DYNAMICS EQUATIONS IN COMPLEX FORM**

H. D. NELSON (Arizona State University, Tempe) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 107, Oct. 1985, p. 460, 461. refs

For a number of years, the finite element method of modeling rotor dynamic systems has been employed extensively. A presentation of rotor system equations in a complex form is convenient for some applications. The present note has the objective to provide the complex form of the rigid disk, finite rotating shaft element, and general linear bearing equations of motion. Order reduction by static condensation, assembly of the system equations, and analysis procedures, are carried out in the same manner as described by Ruhl and Booker (1972), Nordman (1974), and Nelson and McVaugh (1976). G.R.

**A86-16090**

**APPLICATION OF PULSED REFLECTION HOLOGRAPHY TO MATERIAL TESTING**

R. L. VAN RENESSE and J. W. BURGMEIJER (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Delft, Netherlands) Optical Engineering (ISSN 0091-3286), vol. 24, Nov.-Dec. 1985, p. 1086-1092. Research supported by Rijksverdedigingsorganisatie voor Toegepast-Natuurwetenschappelijk Onderzoek. refs

A processing technique resulting in high quality reflection holograms is described. The pulse reflection holograms produced may be analyzed by microscope up to interference fringe densities of about 30 fringes/mm. An experimental study using the holographic technique for the detection of fatigue crack growth in a critical aircraft structure is discussed. Low-noise high-efficiency Denisyuk (1963) phase reflection holograms can be produced by the technique. Holograms of a quality sufficient for the convenient interferometric evaluation of low-diffuse reflectance objects are obtained. In addition, the technique provides a low emulsion shrinkage, making possible shrinkage manipulation and thus reconstructed-color manipulation. Rigid-body motion problems are readily solved if the plate holder is fixed to the object. Finally, sensitivity to in-plane as well as out-of-plane deformation is obtained through the observation of different angles of the objects. F.J.

**N86-12399** Joint Publications Research Service, Arlington, Va.

**CHINA REPORT: SCIENCE AND TECHNOLOGY**

17 Oct. 1985 154 p refs Transl. into ENGLISH from various Chinese articles
(JPRS-CST-85-035) Avail: NTIS HC A08/MF A01

Advances in science and technology by the Peoples Republic of China are reported. Topics of discussion include; (1) national development; (2) physical sciences; (3) applied sciences; (4) astronautics; (5) chemistry; (6) computers; (7) cryogenics; (8) electronics; (9) engineering; (10) mathematics; (11) physics; (12) semiconductors; and (13) solar energy.

**N86-12446#** Joint Publications Research Service, Arlington, Va.

**CHINA REPORT: SCIENCE AND TECHNOLOGY**

3 Sep. 1985 171 p refs Transl. into ENGLISH from various Chinese articles
(JPRS-CST-85-029) Avail: NTIS HC A08/MF A01

Numerous topics related to science and technology in China are discussed. The progess of inertial confinement research, a programmer for a single chip microprocessor, digital voltmeter technology acquisition wing tip sails on the Y-5 aircraft are among the topics discussed.

**N86-12495#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**RADIO-ABSORBING MATERIALS**

Y. A. SHNEYDERMAN 16 Jul. 1985 64 p Transl. into ENGLISH from Zarubezhneya Radioelektron. (USSR), no. 4, 1965 p 115-135
(AD-A157496; FTD-ID(RS)T-1326-84) Avail: NTIS HC A04/MF A01 CSCL 17D

Recently abroad in connection with rapid development of radar technology methods and means of antiradar protection of flight vehicles, which facilitate breach/inrush of aircraft and rockets through lines of air defense intensively are developed/processed. On the intensification of works in this direction it is possible to judge a sharp increase in the expenditures of USAF (United States Air Force) for the development of the combat means with radar - with 35.5 million dollars in 1962 to 119 million dollars in 1963 and 155 million dollars each in 1964. Utilization of radio-absorbing materials, which ensure decrease of effective surface of scattering of aircraft and rockets, is one of effective combat means with radar. GRA

**N86-12552#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean engineering.

### NUMERICAL AND EXPERIMENTAL STUDIES OF 3-D AND UNSTEADY TURBULENT BODY/APPENDAGE/PROPELLER FLOWS Annual Report, No. 2, 15 May 1984 - 14 May 1985

J. A. SCHETZ and R. L. SIMPSON 15 Jun. 1985 56 p
(Contract N00014-83-K-0372)
(AD-A157078) Avail: NTIS HC A04/MF A01 CSCL 20D

The 3-D, turbulent flowfield produced by a propeller operating in the wake of a variable mesh disk has been studied with numerical solutions of the Reynolds-averaged, Navier-Stokes equations and by detailed experiments in a wind tunnel. The mesh variations of the upstream disk were chosen to produce a simulation of the wake of a streamlined, axisymmetric body with a single, streamlined appendage. Comparisons of measurements and preliminary numerical predictions show good agreement for the velocity profiles behind the propeller. The 3-D flow in the junction between a cylindrical appendage and a hull can produce separation of the trailing portion of the appendage and produces a momentum deficient 3-D boundary layer that is more prone to detachment than the 2-D regions away from the appendage. Detailed measurements of the zero-pressure-gradient boundary layer upstream of an appendage of interest have been made. A procedure has been developed for reducing blockage effects in the test wind tunnel. GRA

**N86-12580*#** Spectron Development Labs., Inc., Costa Mesa, Calif.

### OPTICAL TECHNIQUE TO STUDY THE IMPACT OF HEAVY RAIN ON AIRCRAFT PERFORMANCE Final Report

C. F. HESS and F. LI Oct. 1985 43 p refs
(Contract NAS1-17932)
(NASA-CR-177989; NAS 1.26:177989; SDL-85-2424-1F) Avail: NTIS HC A03/MF A01 CSCL 01C

A laser based technique was investigated and shown to have the potential to obtain measurements of the size and velocity of water droplets used in a wind tunnel to simulate rain. A theoretical model was developed which included some simple effects due to droplet nonsphericity. Parametric studies included the variation of collection distance (up to 4 m), angle of collection, effect of beam interference by the spray, and droplet shape. Accurate measurements were obtained under extremely high liquid water content and spray interference. The technique finds applications in the characterization of two phase flows where the size and velocity of particles are needed. Author

**N86-12585#** Department of the Air Force, Washington, D.C.

### TRANSIENT TEST OF SUSPENSION ELECTRONICS FOR GYROSCOPE Patent Application

P. H. ITO, inventor (to Air Force) 8 Jul. 1985 48 p
(AD-D011853; US-PATENT-APPL-SN-752767) Avail: NTIS HC A03/MF A01 CSCL 17G

The rotor suspension electronics of an electrostatic gyro suspension system is required to perform flawlessly to sustain the life of the gyro. Transient abnormalities as short as one millisecond duration will cause the spinning rotor to come in contact with the surrounding electrodes and result in destruction of the gyro. Thus, not infrequently after a catastrophic dropped rotor incident no trace of the fault is evident upon ensuing check of the system. To remedy this problem a built in test (BIT) system is used to provide fault isolation. The test circuitry is built into the navigation system electronics and integrated with the system program. The fault isolation electronics comprise sensor circuits to monitor functional subdivisions of the electronic suspension system for signal abnormality and a processing circuit which receives the sensor circuit outputs and identifies the primary source of the fault. The faults are detected and the source is flagged at the time of occurrance. The output of the fault isolation electronics is a latched coded readout which is fed to the navigation computer for memory storage and any appropriate follow-up system action, such as power shutdown. After initialization by the computer, the fault isolation function is an automatic operation by the electronic circuitry. Author (GRA)

**N86-12595#** Sandia National Labs., Albuquerque, N. Mex.

### NEW PASSIVE HELICOPTER DETECTOR

G. R. ELLIOTT 1985 7 p Presented at the 26th Ann. Meeting of the Inst. of Nucl. Mater. Management, Albuquerque, N. Mex., 21; Jul. 1985
(Contract DE-AC04-76DP-00789)
(DE85-015160; SAND-85-1670C; CONF-850765-9) Avail: NTIS HC A02/MF A01

Sandia has developed a new helicopter detector. The device relies on the correlation between the acoustic wave from the helicopter and the resulting coupled seismic wave. A significant feature of this approach is that the detector is completely passive; there is no radio frequency radiation. Intended for deployment as a perimeter sensor around a site, the unit offers a low nuisance/false alarm rate and a high probability of detection for a wide range of helicopters. Reliable detection occurs when the target is at high altitude and also very near the earth's surface. Detection ranges start at one kilometer for the small, four-place, civilian helicopter and approach five kilometers for heavier, military types. The system has two parts: a transducer package containing a micrphone and a geophone and a digital processor. Development is underway for a model which will be AC powered and well suited to permanent facilities. A prototype unit using a lightweight, battery powered processor is being constructed for rapid-deployment applications. DOE

**N86-12620#** Materials Research Labs., Ascot Vale (Australia).

### DEVELOPMENT AND EVALUATION OF A MICROBURST TEST APPARATUS FOR USE AS A MINIMUM DESTRUCTIVE TEST FOR PARACHUTE MATERIAL

G. T. EGGLESTONE, N. M. BROWNE, and M. TAYLOR Apr. 1985 33 p
(AD-A158110; MRL-R-959) Avail: NTIS HC A03/MF A01 CSCL 11E

Conventional testing of parachute canopy materials to identify the extent of polymer degradation requires large amounts of material resulting in extensive repairs if the material is found to be sound. A microburst test apparatus designed and built at the Materials Research Labs is capable of testing the canopy in-situ, with a degree of damage confined to a 3.2 mm diameter hole. This does not require repair and fits between a ripstop repeat on canopy material from modern day T-1 0 parachutes. The microburst unit gives a digital readout for maximum pressure to burst and pressure to burst/time integral. Correlations between these results and those from conventional tensile and Mullens burst tests showed the microburst test results to more closely resemble those from accepted tensile test methods. GRA

**N86-13616#** Joint Publications Research Service, Arlington, Va.

### WEST EUROPE REPORT: SCIENCE AND TECHNOLOGY

8 Nov. 1985 49 p Repr. from various West European articles Transl. into ENGLISH from various West European articles
(JPRS-WST-85-031) Avail: NTIS HC A03/MF A01

The FBIS West Europe Report (Science and Technology) of 8 November 1985 includes items in the following categories: Advanced Materials, the European Automobile Industry, Biotechnology, Civil Aviation, Computers, Microelectronics, and Scientific and Industrial Policy. Of special interest in this issue are articles on the Franco-Italian ATR-42 aircraft, new CMOS gate arrays produced at Thomson Semiconductors in France, the use of organo-metallic epitaxy to produce chips, and custom chips produced by European Silicon Structures.

**N86-13677*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### HEAT TRANSFER AND PRESSURE DROP PERFORMANCE OF A FINNED-TUBE HEAT EXCHANGER PROPOSED FOR USE IN THE NASA LEWIS ALTITUDE WIND TUNNEL

G. J. VANFOSSEN Nov. 1985 27 p refs
(NASA-TM-87151; E-2623; NAS 1.15:87151) Avail: NTIS HC A03/MF A01 CSCL 20D

A segment of the heat exchanger proposed for use in the NASA Lewis Altitude Wind Tunnel (AWT) facility has been tested under dry and icing conditions. The heat exchanger has the largest pressure drop of any component in the AWT loop. It is therefore critical that its performance be known at all conditions before the final design of the AWT is complete. The heat exchanger segment is tested in the NASA Lewis Icing Research Tunnel (IRT) in order to provide an icing cloud environment similar to what will be encountered in the AWT. Dry heat transfer and pressure drop data are obtained and compared to correlations available in the literature. The effects of icing sprays on heat transfer and pressure drop are also investigated. Author

**N86-13704#** Argonne National Lab., Ill.

**FLUID FORCES ON TWO CIRCULAR CYLINDERS IN CROSSFLOW**

J. A. JENDRZEJCZYK and S. S. CHEN Jun. 1985 60 p
(Contract W-31-109-ENG-38)
(DE85-014294; ANL-85-35) Avail: NTIS HC A04/MF A01

Fluid excitation forces are measured in a water loop for two circular cylinders arranged in tandem and normal to flow. The Strouhal number and fluctuating drag and lift coefficients for both cylinders are presented for various spacings and incoming flow conditions. Results show the effects of Reynolds number, pitch ratio, and upstream turbulence on the fluid excitation forces. DOE

**N86-13756#** Arnold Engineering Development Center, Arnold Air Force Station, Tenn.

**CRUSHING STRENGTH OF ALUMINUM OXIDE AGGLOMERATES Final Report, Apr. 1983 - Sep. 1984**

R. A. GAMBLE Jul. 1985 40 p Prepared in cooperation with Sverdrup Technology, Inc., Arnold AFS, TN
(AD-A158051; AEDC-TR-85-16) Avail: NTIS HC A03/MF A01 CSCL 20K

Aluminum oxide, which is formed during combustion of aluminum-based solid propellants, condenses and solidifies in the exhaust flow to form sub-micron-size particles, which may then adhere together to form agglomerates. Particle sampling, which is required for motor performance or environmental impact investigations, is usually done using a probe placed in the supersonic exhaust flow field. The bow shock at the sample probe inlet will decelerate the gas flow which introduces a large velocity differential between the gas and particulate. This differential will result in a sudden increase on the aerodynamic drag on the agglomerates which may cause them to shear apart, thus altering the sample size distribution. In this effort, aluminum oxide agglomerates were formed and then crushed in order to estimate the magnitude of the interparticle forces binding the agglomerate together. The agglomerates were formed by tumbling commercially available aluminum oxide powder in a container, and strength was determined by measuring the load required to crush the agglomerate between two flat plates. Analysis indicated that through, uniformly-shaped particles formed the strongest agglomerates. The experimentally-derived particle bonding forces were in agreement with values predicted by the van der Waal force equation for closely-spaced spheres. Rocket exhaust particulates collected from a test facility exhaust processing system proved to be unstable because of impurities. GRA

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# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-13467**

**ENVIRONMENT PROTECTION IN CONNECTION WITH AIR TRANSPORTATION [ZASHCHITA OKRUZHAIUSHCHEI SREDY PRI AVIATRANSPORTNYKH PROTSESSAKH]**

V. G. ENENKOV, P. M. ZHELTOV, B. N. MELNIKOV, V. G. LUCHNIKOV, G. E. LAGUTINA et al. Moscow, Izdatel'stvo Transport, 1984, 200 p. In Russian. refs

The physical, organizational and legal aspects of environment protection in connection with air transportation are reviewed. In particular, attention is given to the pollution control of atmospheric air, soil, and water; noise pollution control; and emission control of aviation engines. The discussion also covers the control of sonic boom and the control of radio- and infrasonic-frequency electromagnetic fields. V.L.

**A86-13535**

**WAVES DUE TO A STEADILY MOVING SOURCE ON A FLOATING ICE PLATE**

J. W. DAVYS, R. J. HOSKING, and A. D. SNEYD (Waikato, University, Hamilton, New Zealand) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 158, Sept. 1985, p. 269-287. refs

The propagation of flexural waves in floating ice plates is governed by two restoring forces - elastic bending of the plate, and the tendency of gravity to make the upper surface of the supporting water horizontal. This paper studies steady wave patterns generated by a steadily moving source on a water-ice system that is assumed to be homogeneous and of infinite horizontal extent, using asymptotic Fourier analysis to give a simple description of the wave pattern far from the source. Short-wavelength elastic waves propagate ahead, while the long gravity waves appear behind; and, depending on the system parameters, one, two, or no caustics may appear. Wavecrest patterns are shown, and the amplitude variation with direction from the source is given. Where the two caustics just merge together, a special mathematical function analogous to the Airy function is introduced to describe wave amplitudes. These waves can be detectd by a strainmeter embedded in the ice, and its theoretical response is compared with some experimental measurements. Author

**A86-14816**

**MICROBURSTS - A HAZARD FOR AIRCRAFT**

P. F. LINDEN and J. E. SIMPSON (Cambridge University, England) Nature (ISSN 0028-0836), vol. 317, Oct. 17, 1985, p. 601, 602. refs

Laboratory experiments are reported which show that when a descending column of dense fluid reaches the ground and begins to spread out horizontally, an intense vortex with a horizontal axis forms at the leading edge of the outflowing air. The intensity of this vortex results from the increase in vorticity due to the rapid stretching of the length of the leading edge. The properties of such a horizontal vortex with its associated updrafts and downdrafts are consistent with those found in microbursts, which are a severe hazard to aircraft when taking off or landing. C.D.

**A86-15886#**
**WIND SHEAR INDUCED BY SOLITARY WAVES IN THE LOWER ATMOSPHERE**
L. C. CHIEN (Academia Sinica, Institute of Physics, Taipei, Republic of China), Y. L. LEE (China Airlines, Flight Operation Div., Taipei, Republic of China), and C. Y. LEE (Feng Chia University, Taichung, Republic of China) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-410)

The present solitary wave theory of wind shears responsible for aircraft accidents is not easily verified by the existing meteorological record, which lacks the requisite resolution and sensitivity to indicate the presence of such waves at the time of an accident. Nevertheless, lower atmosphere solitary waves have been surveyed at Warramunger, Australia, since 1976, over scales ranging from some tens of meters to more than 10 km. Recommendations are made for further study. O.C.

**N86-12680#** Joint Publications Research Service, Arlington, Va.
**GRAVIMETRIC SURVEYING WITH MI-8 HELICOPTERS Abstract Only**
V. SOPOLEV *In its* USSR Rept.: Earth Sci. (JPRS-UES-85-006) p 52 19 Jun. 1985 Transl. into ENGLISH from Vozdushnyy Transport (Moscow), 18 Apr. 1985 p 4
Avail: NTIS HC A05/MF A01

A new type of geophysical operation--gravimetric surveying from MI-8 helicopters with the aid of suspended gravimeters--has been mastered for the first time in the country by Far East helicopter crews. In this method, all work is performed by an operator inside a helicopter carrying a gravimeter on an outside sling. The gravimeter is equipped with a stabilizing device. Work with the suspended gravimeter requires considerable flying skill and highly precise piloting during approaches and hovering. Author

**N86-12744#** Naval Ocean Research and Development Activity, Bay St. Louis, Miss.
**DATA ANALYSIS OF AIRBORNE ELECTROMAGNETIC BATHYMETRY Final Report**
R. ZOLLINGER, A. BECKER, and F. MORRISON Apr. 1985 21 p
(AD-A157132; NORDA-93) Avail: NTIS HC A02/MF A01 CSCL 08J

This report describes an experimental evaluation of the concept of airborne electromagnetic bathymetry. The airborne electromagnetic data that forms the basis of this project was acquired with the Mark VI INPUT system along a 17-mile-long flight path off Cape Breton Island in the province of Nova Scotia. The water depth beneath the flight path ranged from 0 to more than 40 m. Author (GRA)

**N86-12915#** Meteorological Satellite Center, Tokyo (Japan).
**INTRODUCTION TO OPERATIONAL ASDAR SYSTEM**
M. HITANI *In its* Meteorol. Satellite Center Tech. Note, No. 11, 1985 p 55-60 Mar. 1985 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A06/MF A01

ASDAR (Aircraft to Satellite Data Relay) is the meteorological avionics systems which automatically sample, record and transmit meteorological observations. The operational ASDAR unit transmits additional information compared with the prototype unit which has continued to function still in service. The initial deliveries of the new flight units are expected dy mid-1985. The data collection system will be revised to process the new ASDAR data. Author

**N86-13832#** Westinghouse Electric Corp., Lima, Ohio. Electrical Systems Div.
**TWO-HUNDRED TO 300 KVA CONDITIONED POWER SYSTEM - DEVELOPMENT, PHASE 1 Final Report, Sep. 1982 - Mar. 1984**
W. E. HYVARINEN Mar. 1985 409 p
(Contract F33615-82-C-2234)
(AD-A158820; REPT-1383R; AFWAL-TR-84-2065) Avail: NTIS HC A18/MF A01 CSCL 10B

Future large AF electrical generator channels will be required to operate in parallel to supply single large loads. These channels will be required to use a minimum number of conversion stages to maintain the highest possible efficiency. The EW or other large loads will use power converted directly from the variable speed generator, and only that power required to be 400-Hz will be converted by the V.S.C.F. unit. Redundancy for one generator out condition will be required. The protection and control of the parallel bus will require more sophistication and complexity than the systems presently available. Large rating generators, contactors, and distribution systems will require design effort and test. This report covers a design study to meet the requirements of advanced high power EW systems for aircraft. This report covers the design of a 50 kVA, six-phase generator which is spray oil cooled. The output ratings are 60 kVA at 53% speed, 120 kVA at 60% speed and 410 kVA above 83% speed. The generator maximum design speed is 15,000 rpm. GRA

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## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-13944#**
**CHANGES OF FLYING SKILLS DURING NON-FLIGHT PERIODS**
Z. KATOH, A. KADOO, Y. NAGASAWA, T. OBATA, and N. IGUCHI Japan Air Self Defence Force, Aeromedical Laboratory, Reports (ISSN 0023-2858), vol. 26, June 1985, p. 81-104. In Japanese, with abstract In English. refs

Flight data from 28 training pilots were analyzed with respect to changes in flying skill during non-flight periods. On board flight data recordings and questionnaries concerning the self-estimation of pilot skill were evaluated with respect to three maneuvers: vertical S-Alpha (VSA); a steep turn (STP); and a horizontal turn (HRZ). A brief summary of the results is provided. I.H.

**N86-12968#** Air Command and Staff Coll., Maxwell AFB, Ala.
**THE HELICOPTER TO FIXED WING CONVERSION PROGRAM: A CRITICAL REVIEW**
L. T. MASSEY Apr. 1985 39 p
(AD-A156820; ACSC-85-1750) Avail: NTIS HC A03/MF A01 CSCL 05I

USAF helicopter pilots are initially trained by the U.S. Army through their undergraduate helicopter pilot training program. Four to seven years later, some of these pilots have the opportunity to convert to fixed wing aircraft via the fixed wing conversion program currently conducted by sending selected helicopter pilots through Air Force undergraduate pilot training. This study reviews these programs and assesses the impact this training philosophy has on career opportunities for helicopter pilots, both for those who convert to fixed wing systems, as well as for those who remain in helicopters. Two alternatives are presented which would resolve the problems identified. The study concludes that the USAF could provide better career opportunities for helicopter pilots, as well as improve experience levels in the helicopter force, by enacting changes to current training programs. Author (GRA)

**N86-12973#** Systems Research Labs., Inc., Dayton, Ohio.
**CRITERIA FOR A STATE-OF-THE-ART VISION TEST SYSTEM Final Report**
K. MOFFITT and L. V. GENCO May 1985 109 p
(Contract F33615-82-C-0511)
(AD-A157099; AFAMRL-TR-85-004) Avail: NTIS HC A06/MF A01 CSCL 06P

Many vision test/screening devices used in the Armed Services have not changed since the 1940's. The reduction in the size of the pool of qualified aircrew candidates has caused operational Commands to question the validity of these tests. Current objectives of vision testing have evolved from a means to eliminate pilot candidates to methods of predicting aircrew performance. The Naval Aerospace Medical Research Laboratory (NAMRL) is attempting to correlate the results of several vision tests with the visual abilities of pilot trainees as demonstrated during monitored training flights. This report describes status that could be considered as useful parameters for testing in the Armed Forces vision test battery of the future. One major conclusion is that the operational visual task(s) must be suitably described in order to select appropriate clinical and laboratory test measures. Correlations and validation studies can then be performed with cooperative efforts such as those between NAMRL and AFAMRL. GRA

**N86-13890#** Air Force Human Resources Lab., Brooks AFB, Tex.
**PILOT-ORIENTED PERFORMANCE MEASUREMENT Final Report, Jan. - Dec. 1983**
J. DEMAIO, H. H. BELL, and J. BRUNDERMAN Aug. 1985 15 p
(Contract AF PROJ. 2313)
(AD-A158849; AFHRL-TP-85-18) Avail: NTIS HC A02/MF A01 CSCL 14B

Aircrew performance measurement is a critical problem in evaluating the quality of a visual simulation system and in determining the effectiveness of aircrew training devices. An effective performance measurement system must be able to separate performance into appropriate components and describe the relationship of these components. This paper describes a performance measurement system developed to analyze pilot performance in maintaining altitude in both straight and turning flight as a function of the object density of the simulated visual environment. The analysis indicates that pilot performance can be divided into perceptual and task difficulty factors and that the effect of the visual environment on each of these factors can be determined. A prototype performance measurement system was developed to describe pilot performance in a simulator. The pilot's task was to maintain altitude at 200 feet both in straight and in turning flight. Pilot performance was sensitive to task difficulty and to visual scene quality. The strength of this performance measurement system was that it analyzed performance in terms of overall task performance and also specific pilot control inputs. GRA

**N86-13892*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**EFFECTS OF DIGITAL ALTIMETRY ON PILOT WORKLOAD**
R. L. HARRIS, SR. and B. J. GLOVER Nov. 1985 20 p refs
(NASA-TM-86424; L-15989; NAS 1.15:86424) Avail: NTIS HC A02/MF A01 CSCL 05H

A series of VOR-DME instrument landing approaches was flown in the DC-9 full-workload simulator to compare pilot performance, scan behavior, and workload when using a computer-drum-pointer altimeter (CDPA) and a digital altimeter (DA). Six pilots executed two sets of instrument landing approaches, with a CDPA on one set and a DA on the other set. Pilot scanning parameters, flight performance, and subjective opinion data were evaluated. It is found that the processes of gathering information from the CDPA and the DA are different. The DA requires a higher mental workload than the CDPA for a VOR-DME type landing approach. Mental processing of altitude information after transitioning back to the attitude indicator is more evident with the DA than with the CDPA. E.A.K.

**N86-13906#** Purdue Univ., West Lafayette, Ind.
**ALERTED MONITORS: HUMAN OPERATORS AIDED BY AUTOMATED DETECTORS Final Report**
R. D. SORKIN and D. E. ROBINSON Dec. 1984 55 p
(Contract DTRS56-83-C-00047)
(PB85-222750; DOT/OST/P34-85/021) Avail: NTIS HC A04/MF A01 CSCL 05H

In an alerted monitor system, an automated detector assists a human operator in the detection and diagnosis of problems occurring in some monitored process. Air traffic control centers and the flight decks of commercial aircraft include many examples of such systems. This project developed a general model of the altered-monitor system and evaluated the effects on system performance of interactions between the human operator and automated detector. One of the types of interaction evaluated (contingent criterion strategy) yields optimal performance from the combined person-machine system. Two laboratory experiments were performed to evaluate the assumptions of the model and the interactions between the operator and automated components. GRA

## 15

## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-13049**
**HARDWARE INTEGRITY**
W. J. CULLYER (Royal Signals and Radar Establishment, Malvern, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Aug.-Sept. 1985, p. 263-268. refs

The presently reported research has revealed problems with the use of commercial microprocessors in safety-critical equipment, due to imprecise documentation of the instruction sets issued by manufactures and changes in design and function over the years in which a commercially popular device is marketed. Attention is presently given to the development of formal methods for the design and implementation of VLSI chips for certain research applications, in which the chips furnish simple processing functions and can be proved to be functionally correct. The novel 32-bit microprocessor architecture designatted 'VIPER' is taken as an illustrative case. O.C.

**A86-13125**
**FLEXIBLE ASSEMBLY SUBSYSTEMS**
O. WEINGART (Rohr Industries, Inc., Riverside, CA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 820-831.

A three-year Flexible Assembly Subsystems program was conducted in order to develop and demonstrate technologies that are critical for the achievement of flexible automated systems. The ultimate goal of this work is the furnishing of a technology base for the automation of military airframe assembly. Phase I of the program gives attention to hardware requirements, risk reduction, and simulation. Phase II will undertake component refinement, total system integration, and final demonstration of capabilities. O.C.

**A86-13409**

**A METHOD FOR ARRANGING NODES ALONG THE LINES OF A COMPUTATIONAL GRID DURING THE NUMERICAL SOLUTION OF PROBLEMS IN MATHEMATICAL PHYSICS [METOD RASSTANOVKI UZLOV VDOL' LINII SCHETNOI SETKI PRI CHISLENNOM RESHENII ZADACH MATEMATICHESKOI FIZIKI]**

V. L. IUMASHEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 4, 1984, p. 115-119. In Russian.

Automatic grid generation during the numerical solution of problems in mathematical physics involves the problem of node arrangment along an arbitrary line in accordance with a given criterion. A numerical method for solving this problem is proposed which can be used in a sufficiently general case where the line and the node arrangement criterion are given in the form of certain computational procedures rather than in analytical form. The method is illustrated by an example in which a grid is constructed for a body with a variable-width elliptical cross-section representing a flight vehicle model. V.L.

**A86-13418**

**APPLICATION OF THE STATE-SPACE METHOD TO ANALYZE THE STABILITY OF DIGITAL SYSTEMS [PRIMENENIE METODA PROSTRANSTVA SOSTOIANII DLIA ANALIZA USTOICHIVOSTI TSIFROVYKH SISTEM]**

IU. I. DIDENKO, P. V. KUSHNIR, and IU. F. SHELIUKHIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 68-78. In Russian. refs

Methodological questions involving the use of state equations to analyze the stability of complex digital systems are examined. Consideration is given to delay in the feedback circuits, the use of several reception beats of input information, and the renewal of the state-vector components of the digital controlling part. Generalized matrix expressions describing the behavior of such systems are obtained. A digital flight control system is considered as an example. B.J.

**A86-14434*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EXPERT SYSTEMS AND THEIR USE IN AUGMENTING DESIGN OPTIMIZATION**

G. H. KIDWELL and M. A. ESKEY (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 16 p. refs

(AIAA PAPER 85-3095)

The challenging requirements that are evolving for future aircraft demand that each design be optimally integrated, for the penalties imposed by nonoptimal performance are significant. Classic numerical optimization algorithms have been and will continue to be important tools for aircraft designers. These methods are, however, limited to certain categories of aircraft design variables, leaving the remainder to be determined by the user. A method that makes use of knowledge-based expert systems offers the potential for aiding the conceptual design process in a way that is similar to that of numerical optimization, except that it would address discrete, discontinuous, abstract, or any other unoptimized aspect of vehicle design and integration. Other unique capabilities such as automatic discovery and learning in design may also be achievable in the near term. This paper discusses current practice in conceptual aircraft design and knowledge-based systems, and how knowledge-based systems can be used in conceptual design. Author

**A86-14827**

**UNCERTAINTY AND CONTROL - SOME ACTIVITIES AT DFVLR**

G. GRUEBEL (DFVLR, Institut fuer Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany) IN: Uncertainty and control; Proceedings of the International Seminar, Bonn, West Germany, May 1985 . Berlin and New York, Springer-Verlag, 1985, p. 1-47. refs

Some activities at DFVLR which deal with system modelling and performance evaluation under uncertainty, as well as feedback control applications, are reported. Activities in applied nonlinear parameter identification, on-line wind measurement and prediction, stochastic simulation, and sensor diagnosis via analytic redundancy are briefly described. Applications of feedback control are examined, including model-following control for inflight simulation, robust stabilization of high-performance aircraft, aircraft flutter stability augmentation via active mode decoupling, and active damping of mechanical lightweight structures based on finite element modelling. C.D.

**A86-14830**

**MULTI-MODEL APPROACHES TO ROBUST CONTROL SYSTEM DESIGN**

J. ACKERMANN (DFVLR, Institut fuer Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany) IN: Uncertainty and control; Proceedings of the International Seminar, Bonn, West Germany, May 1985 . Berlin and New York, Springer-Verlag, 1985, p. 108-130. refs

The design of fixed-gain, robust controllers is reviewed. Two design methods are considered: (1) the simultaneous assignment of the poles to a given region for all members of the plant family by parameter space methods, and (2) the interactive Pareto optimization of a vectorial performance index. The testing of the controller for parameter uncertainty in continuous intervals is examined. The existence and dynamic order of simultaneous Gamma stabilizers is discussed. C.D.

**A86-15278**

**APPLICATIONS OF ARTIFICIAL INTELLIGENCE; PROCEEDINGS OF THE MEETING, ARLINGTON, VA, MAY 3, 4, 1984**

J. F. GILMORE, ED. (Georgia Institute of Technology, Atlanta) Meeting sponsored by SPIE - The International Society for Optical Engineering. Bellingham, WA, SPIE - The International Society for Optical Engineering (SPIE Proceedings. Volume 485), 1984, 243 p. For individual items see A86-15279 to A86-15285.

(SPIE-485)

Subjects related to expert systems are discussed, taking into account a context dependent automatic target recognition system, computer understanding of air traffic control displays, the role of the image analyst in computer vision, a demonstration of an ocean surveillance information fusion expert system, and the location of multiple faults by diagnostic expert systems. Other topics explored are concerned with knowledge-based systems, autonomous vehicles, and image understanding. Attention is given to aspects of interfacing an intelligent decision-maker to a real-time control system, a reasoning system for computer aided engineering, an 'intelligent' optical design program, an adaptive interpolator algorithm for area-array fine guidance sensors, terrain navigation concepts for autonomous vehicles, the autonomous helicopter system, an autonomous vehicle navigation algorithm, the planning of strategic paths through variable terrain data, the contextual analysis of tactical scenes, and a structural target analysis and recognition system. G.R.

**A86-15283**
**AIRID - AN APPLICATION OF THE KAS/PROSPECTOR EXPERT SYSTEM BUILDER TO AIRPLANE IDENTIFICATION**
J. P. ALDRIDGE (Los Alamos National Laboratory, NM) IN: Applications of artificial intelligence; Proceedings of the Meeting, Arlington, VA, May 3, 4, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 73-79.

The Knowledge Acquisition System/Prospector expert system building tool has been used to construct an expert system to identify aircraft on the basis of observables such as wing shape, engine number/location, fuselage shape, and tail assembly shape. Additional detailed features are allowed to influence the identification as 'other favorable features'. Constraints on the observations imposed by bad weather and distant observations have been included as contexts to the models. Models for Soviet and U.S. fighter aircraft have been included. Inclusion of other types of aircraft such as bombers, transports, and reconnaissance craft is straightforward. Two models permit exploration of the interaction of semantic and taxonomic networks with the models. A full set of text data for fluid communication with the user has been included. The use of demons as triggered output responses to enhance utility to the user has been explored. This paper presents discussion of the ease of building the expert system using this powerful tool and problems encountered in the construction process. Author

**N86-13051#** Federal Aviation Administration, Washington, D.C. Office of Aviation Policy and Plans.
**STATISTICAL SAMPLING OF AIRCRAFT OPERATIONS AT NON-TOWERED AIRPORTS**
M. FORD and R. SHIRACK Apr. 1985 49 p
(AD-A157095; FAA-APO-85-7) Avail: NTIS HC A03/MF A01 CSCL 12A

The purpose of this handbook is to provide a statistically sound method of estimating aircraft operations at non-towered airports from sampling counts. The handbook is written for planners, engineers, airport operators responsible for aircraft planning, and persons that collect data for FAA Airport Master Records (Form 5010.1). Many of these users will be familiar with general aviation airports, but not necessarily with statistical methods. Accurate information on aircraft activity at non-towered airports is a major need of airport owners and operators as well as planners and administrators charged with the planning and development of the airport system. Unlike towered airports, where air traffic controllers keep constant tallies of activity, most non-towered airports have no accurate record of usage. Obtaining accurate aircraft activity counts will provide a variety of benefits. Investment decisions can be made with more confidence if benefit-cost analysis is based on accurate information about use of the facility. Design criteria, which may have a significant impact on development and operating costs; can be more efficiently applied. Even when decisions are based on forecasts rather than present circumstances, accurate base data is necessary to make accurate forecasts of activity. GRA

**N86-13922*#** Stanford Univ., Calif. Computer Systems Lab.
**DEVELOPMENT OF A FLIGHT SOFTWARE TESTING METHODOLOGY Final Report**
E. J. MCCLUSKEY and D. M. ANDREWS Sep. 1985 29 p refs
(Contract NAG2-246)
(NASA-CR-176391; NAS 1.26:176391) Avail: NTIS HC A03/MF A01 CSCL 09B

The research to develop a testing methodology for flight software is described. An experiment was conducted in using assertions to dynamically test digital flight control software. The experiment showed that 87% of typical errors introduced into the program would be detected by assertions. Detailed analysis of the test data showed that the number of assertions needed to detect those errors could be reduced to a minimal set. The analysis also revealed that the most effective assertions tested program parameters that provided greater indirect (collateral) testing of other parameters. In addition, a prototype watchdog task system was built to evaluate the effectiveness of executing assertions in parallel by using the multitasking features of Ada. Author

**N86-13944*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THE MISSION ORIENTED TERMINAL AREA SIMULATION FACILITY**
J. T. KAYLOR, H. I. SIMMONS, P. B. NAFTEL (Research Triangle Inst.), J. A. HOUCK, and R. D. GROVE Oct. 1985 63 p refs
(NASA-TM-87621; NAS 1.15:87621) Avail: NTIS HC A04/MF A01 CSCL 09B

The Mission Oriented Terminal Area Simulation (MOTAS) was developed to provide an ATC environment in which flight management and flight operations research studies can be conducted with a high degree of realism. This facility provides a flexible and comprehensive simulation of the airborne, ground-based and communication aspects of the airport terminal area environment. Major elements of the simulation are: an airport terminal area environment model, two air traffic controller stations, several aircraft models and simulator cockpits, four pseudo pilot stations, and a realistic air-ground communications network. MOTAS has been used for one study with the DC-9 simulator and a series of data link studies are planned in the near future. Author

**N86-13946*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A METHOD TO STABILIZE LINEAR SYSTEMS USING EIGENVALUE GRADIENT INFORMATION**
C. D. WIESEMAN Nov. 1985 40 p refs
(NASA-TP-2479; L-15964; NAS 1.60:2479) Avail: NTIS HC A03/MF A01 CSCL 09B

Formal optimization methods and eigenvalue gradient information are used to develop a stabilizing control law for a closed loop linear system that is initially unstable. The method was originally formulated by using direct, constrained optimization methods with the constraints being the real parts of the eigenvalues. However, because of problems in trying to achieve stabilizing control laws, the problem was reformulated to be solved differently. The method described uses the Davidon-Fletcher-Powell minimization technique to solve an indirect, constrained minimization problem in which the performance index is the Kreisselmeier-Steinhauser function of the real parts of all the eigenvalues. The method is applied successfully to solve two different problems: the determination of a fourth-order control law stabilizes a single-input single-output active flutter suppression system and the determination of a second-order control law for a multi-input multi-output lateral-directional flight control system. Various sets of design variables and initial starting points were chosen to show the robustness of the method. Author

**N86-14104*#** Bradley Univ., Peoria, Ill. Dept. of Mathematics.
**COMPUTER GRAPHICS APPLICATIONS TO CREW DISPLAYS Final Report**
J. WYZKOSKI *In* NASA. Johnson (Lyndon B.) Space Center The 1983 NASA/ASEE Summer Faculty Fellowship Research Program Research Reports 10 p Sep. 1983 refs
Avail: NTIS HC A18/MF A01 CSCL 09B

Astronauts are provided much data and information via the monochrome CRT displays on the orbiter. For this project two areas were investigated for the possible introduction of computer graphics to enhance and extend the utility of these displays. One involved reviewing the current orbiter displays and identifying those which could be improved via computer graphics. As an example, the tabular data on electrical power distribution and control was enhanced by the addition of color and bar charts. The other dealt with the development of an aid to berthing a payload with the Remote Manipulator System (RMS). This aid consists of a graphics display of the top, front and side views of the payload and cargo bay and point of resolution (POR) position and attitude data for the current location of the payload. The initial implementation was on an IBM PC clone. The demonstration software installed in the Johnson Space Center Manipulator Development Facility (MD) was reviewed. Due to current hardware limitations, the MDF verision is slow, i.e., about a 40+ seond update rate and, hence, not real-time. Despite this fact, the evaluation of this additional visual cue as an RMS operator aid indicates that this display, with modifications for speed, etc., can assist the crew. Further development is appropriate. Author

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## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-13031**

**RADIATIVE GASDYNAMIC PROCESSES IN IMPLODING DISCHARGES IN A PLASMODYNAMIC MAGNETOPLASMA COMPRESSOR**

A. S. KAMRUKOV, N. P. KOZLOV, IU. S. PROTASOV, and S. N. CHUVASHEV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) (Zhurnal Tekhnicheskoi Fiziki, vol. 55, Mar. 1985, p. 533-543) Soviet Physics - Technical Physics (ISSN 0038-5662), vol. 30, March 1985, p. 315-321. Translation. refs

Radiative gasdynamic processes in collapsing radiating plasmodynamic discharges in magnetoplasma compressors are simulated numerically and the results are compargd with available experimental data. The nonequilibrium ionic composition, the electron-ion temperature stratification, and the vaporization and influx of vaporized material from the transparent channel walls into the plasma in the implosion zone are all found to be important. The interaction between radiation and vaporization appreciably alters the time dependence of the light output relative to the pumping pulse and enhances the light-emitting efficiency of the discharge. Author

**A86-13416**

**ACOUSTIC CHARACTERISTICS OF MODELS OF EJECTOR SUPPRESSORS OF JET NOISE [AKUSTICHESKIE KHARAKTERISTIKI MODELEI EZHEKTORNYKH GLUSHITELEI SHUMA STRUI]**

IU. G. ZHULEV, O. V. LEBEDEVA, A. G. MUNIN, and IU. F. POTAPOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 15, no. 5, 1984, p. 46-53. In Russian. refs

The paper presents the results of an experimental study of the acoustic characteristics of a jet-noise suppressor in the form of a corrugated nozzle and an ejector with sound-absorbing walls. It is shown that a particular combination of outlet-nozzle shapes and ejector dimensions makes it possible to reduce the jet noise to 13 dB in the range of spectrum components where the noise is maximal. This result holds both for stationary conditions and for flight conditions at speeds up to 270 km/hour. B.J.

**A86-15340**

**FIBER OPTICS IN ADVERSE ENVIRONMENTS II; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, AUGUST 22-24, 1984**

R. A. GREENWELL, ED. (Science and Engineering Associates, Inc., Seattle, WA) Meeting sponsored by SPIE - The International Society for Optical Engineering. Bellingham, WA, SPIE - The International Society for Optical Engineering (SPIE Proceedings. Volume 506), 1984, 244 p. For individual items see A86-15341 to A86-15343.
(SPIE-506)

Measurements and characterization of fiber optics in radiation environments are considered, taking into account material dispersion measurements on fiber optic cables used at the Nevada Test Site, gamma-ray to Cerenkov light conversion efficiency for pure-silica-core optical fibers, the measurement of transient radiation effects in optical fibers, optical characterization of radiation-resistant fibers, and a high-bandwidth multichannel fiber optic system for measuring gamma rays. Other topics discussed are related to radiation test monitoring systems using fiber optics, fiber optic systems in adverse environments, fiber optics in the electromagnetic environment, environmental effects on fiber optic components, radiation effects in optical fibers, and radiation effects on fiber optic devices. Attention is given to the radiation response of optical fibers in a nuclear reactor, a fiber optic digital uplink for ocean-floor experimentation, fiber optic aircraft systems electromagnetic pulse (EMP) survivability, and transient attenuation in optical fibers. G.R.

**A86-16058*** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SOUND GENERATION BY FLOW OVER RELATIVELY DEEP CYLINDRICAL CAVITIES**

S. P. PARTHASARATHY, Y. I. CHO, and L. H. BACK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Acoustical Society of America, Journal (ISSN 0001-4966), vol. 78, Nov. 1985, p. 1785-1795. Army-sponsored research. refs

To develop a system for acoustic coding of moving objects containing drilled cylindrical cavities, the production of high-intensity tones by deep cylindrical cavities in a flat surface at low (0.12-0.24) Mach numbers was investigated. The sound intensity and frequency have been determined as functions of flow velocity, diameter, and depth of the cavities. It is shown that whistles can be designed for a given frequency (in the range of 5-17 kHz) and flow, and the sound pressure levels can be calculated by the equations given. Using these equations a whistle producing 106 dB at a 30.5-cm distance from a cylindrical cavity of 0.508 cm in diameter and 1.32 cm in depth with an airflow of 57.7 m/s past the cavity was designed. I.S.

**N86-14006*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PRELIMINARY MEASUREMENT OF THE NOISE FROM THE 2/9 SCALE MODEL OF THE LARGE-SCALE ADVANCED PROPFAN (LAP) PROPELLER, SR-7A**

J. H. DITTMAR Sep. 1985 22 p refs
(NASA-TM-87116; E-2718; NAS 1.15:87116) Avail: NTIS HC A02/MF A01 CSCL 02A

Noise data on the Large-scale Advanced Propfan (LAP) propeller model SR-7A were taken into the NASA Lewis 8- by 6-Foot Wind Tunnel. The maximum blade passing tone decreases from the peak level when going to higher helical tip Mach numbers. This noise reduction points to the use of higher propeller speeds as a possible method to reduce airplane cabin noise while maintaining high flight speed and efficiency. Comparison of the SR-7A blade passing noise with the noise of the similarly designed SR-3 propeller shows good agreement as expected. The SR-7A propeller is slightly noisier than the SR-3 model in the plane of rotation at the cruise condition. Projections of the tunnel model data are made to the full-scale LAP propeller mounted on the test bed aircraft and compared with design predictions. The prediction method is conservative in the sense that it overpredicts the projected model data. Author

**N86-14007*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**SOME DESIGN PHILOSOPHY FOR REDUCING THE COMMUNITY NOISE OF ADVANCED COUNTER-ROTATION PROPELLERS**

J. H. DITTMAR Aug. 1985 29 p refs
(NASA-TM-87099; E-2692; NAS 1.15:87099) Avail: NTIS HC A03/MF A01 CSCL 20A

Advanced counter-rotation propellers have been indicated as possibly generating an unacceptable amount of noise for the people living near an airport. This report has explored ways to reduce this noise level, which is treated as being caused by the interaction of the upstream propeller wakes and vortices with the downstream propeller. The noise reduction techniques fall into two categories: (1) reducing the strength of the wakes and vortices, and (2) reducing the response of the downstream blades to them. The noise from the wake interaction was indicated as being reduced by increased propeller spacing and decreased blade drag coefficient. The vortex-interaction noise could be eliminated by having the vortex pass over the tips of the downstream blade, and it could be reduced by increased spacing or decreased initial circulation. The downstream blade response could be lessened by increasing the reduced frequency parameter omega or by phasing of the response from different sections to have a mutual cancellation effect. Uneven blade to blade spacing for the downstream blading was indicated as having a possible effect on the annoyance of counter-rotation propeller noise. Although there are undoubtedly additional methods of noise reduction not covered in this report, the inclusion of the design methods discussed would potentially result in a counter-rotation propeller that is acceptably quiet. Author

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-14239#**
**SELECTION OF AN OPTIMAL COST INDEX FOR AIRLINE HUB OPERATION**
A. CHAKRAVARTY (Boeing Commercial Airplane Co., Seattle, WA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 182-187) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 777-781. Previously cited in issue 21, p. 3122, Accession no. A84-43421.

**A86-14372**
**LIABILITY OF AIR TRAFFIC CONTROL AGENCIES AND AIRPORT OPERATORS IN CIVIL LAW JURISDICTIONS**
A. E. DU PERRON Air Law (ISSN 0165-2079), vol. 10, Oct. 1985, p. 203-216. refs

**N86-13219*#** Akron Univ., Ohio. Dept. of Civil Engineering.
**NASA LERC/AKRON UNIVERSITY GRADUATE COOPERATIVE FELLOWSHIP PROGRAM AND GRADUATE STUDENT RESEARCHERS PROGRAM Interim Report, Nov. 1981 - Oct. 1983**
D. G. FERTIS Oct. 1983 59 p refs
(Contract NAG3-50; NGT36-001-800; NGT36-001-801)
(NASA-CR-174826; NAS 1.26:174826; NAUFP-202-3) Avail: NTIS HC A04/MF A01 CSCL 05I

On June 1, 1980, the University of Akron and the NASA Lewis Research Center (LERC) established a Graduate Cooperative Fellowship Program in the specialized areas of Engine Structural Analysis and Dynamics, Computational Mechanics, Mechanics of Composite Materials, and Structural Optimization, in order to promote and develop requisite technologies in these areas of engine technology. The objectives of this program are consistent with those of the NASA Engine Structure Program in which graduate students of the University of Akron participate by conducting research at Lewis. This report is the second on this grant and summarizes the second and third year research effort, which includes the participation of five graduate students where each student selects one of the above areas as his special field of interest. Each student is required to spend 30 percent of his educational training time at the NASA Lewis Research Center and the balance at the University of Akron. His course work is judiciously selected and tailored to prepare him for research work in his field of interest. A research topic is selected for each student while in residence at the NASA Lewis Research Center, which is also approved by the faculty of the University of Akron as his thesis topic for a Master's and/or a Ph.D. degree. Author

**N86-13220#** Naval Postgraduate School, Monterey, Calif.
**COMPUTER AIDED INSTRUCTION IN ENGINEERING M.S. Thesis**
T. S. ROSE Mar. 1985 53 p
(AD-A156828; AD-E301723) Avail: NTIS HC A04/MF A01 CSCL 05I

This thesis presents evidence that computer aided instruction (CAI) is effective and can improve instructional efficiency when it is properly implemented. An overview of CAI in other colleges is presented as a source of ideas. The Department of Aeronautics of the Naval Postgraduate School is used as an example of where CAI can be applied. Procedures for the proper implementation of CAI are presented; and the summary includes specific recommendations for the Aeronautics Department. GRA

**N86-13235*#** National Academy of Sciences - National Research Council, Washington, D. C. Panel on Vehicle Applications.
**AERONAUTICAL TECHNOLOGY 2000: A PROJECTION OF ADVANCED VEHICLE CONCEPTS**
1985 116 p
(Contract NASW-3455)
(NASA-CR-176322; NAS 1.26:176322) Avail: NTIS HC A06/MF A01; also available from Aeronautics and Space Engineering Board, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418 CSCL 05A

The Aeronautics and Space Engineering Board (ASEB) of the National Research Council conducted a Workshop on Aeronautical Technology: a Projection to the Year 2000 (Aerotech 2000 Workshop). The panels were asked to project advances in aeronautical technologies that could be available by the year 2000. As the workshop was drawing to a close, it became evident that a more comprehensive investigation of advanced air vehicle concepts than was possible in the limited time available at the workshop would be valuable. Thus, a special panel on vehicle applications was organized. In the course of two meetings, the panel identified and described representative types of aircraft judged possible with the workshop's technology projections. These representative aircraft types include: military aircraft; transport aircraft; rotorcraft; extremely high altitude aircraft; and transatmospheric aircraft. Improvements in performance, efficiency, and operational characteristics possible through the application of the workshop's year 2000 technology projections were discussed. The subgroups also identified the technologies considered essential and enhancing or supporting to achieve the projected aircraft improvements. B.W.

**N86-14078*#** National Aeronautics and Space Administration. Johnson (Lyndon B.) Space Center,
**THE 1983 NASA/ASEE SUMMER FACULTY FELLOWSHIP RESEARCH PROGRAM RESEARCH REPORTS Final Reports**
W. J. HORN, ed. (Texas A&M Univ., College Station) and M. B. DUKE, ed. Sep. 1983 409 p refs Program held in College Station, Tex., 1983
(Contract NGT-44-001-800)
(NASA-CR-171904; NAS 1.26:171904) Avail: NTIS HC A18/MF A01 CSCL 05I

The 1983 NASA/ASEE Summary Faculty Fellowship Research Program was conducted by Texas A&M University and the Lyndon B. Johnson Space Center (JSC). The 10-week program was operated under the auspices of the American Society for Engineering Education (ASEE). The basic objectives of the programs, which began in 1965 at JSC and in 1964 nationally, are (1) to further the professional knowledge of qualified engineering and science faculty members, (2) to stimulate an exchange of ideas between participants and NASA, (3) to enrich and refresh the research and teaching activities of participants' institutions, and (4) to contribute to the research objectives of the NASA Centers. The faculty fellows spent 10 weeks at JSC engaged in a research project commensurate with their interests and background. They worked in collaboration with a NASA/JSC colleague. This document is a compilation of final reports on their research during the summer of 1983.

# 18

## SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

**N86-14111#** Joint Publications Research Service, Arlington, Va.
**USSR REPORT: SPACE**
30 Sep. 1985 156 p refs Transl. into ENGLISH from various Russian articles
(JPRS-USP-85-005) Avail: NTIS HC A08

Progress in USSR aerospace science and technology is reported. Topics discussed include: aerospace engineering, interplanetary sciences, life sciences, space applications, space policy and administration, and launch tables.

# 19

## GENERAL

**A86-13462**
**STUDIES IN THE HISTORY AND THEORY OF THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN THE FIELDS OF AVIATION, ROCKETRY, AND SPACE. NUMBER 3 [ISSLEDOVANIIA PO ISTORII I TEORII RAZVITIIA AVIATSIONNOI I RAKETNO-KOSMICHESKOI NAUKI I TEKHNIKI. NUMBER 3]**
B. V. RAUSHENBAKH, ED. Moscow, Izdatel'stvo Nauka, 1984, 248 p. In Russian. No individual items are abstracted in this volume.

The papers presented in this volume provide an overview of developments in the field of rocket and spacecraft building and manned space flights in the USSR. In particular, attention is given to the analysis of the works of the founders of theoretical space science, problems in the development and building of aviation engines, and methodological problems associated with the study of the development of aerospace systems. V.L.

**A86-15913#**
**A BRIEF HISTORY OF THE FIRST U.S. JATO FLIGHT TESTS OF AUGUST 1941**
H. A. BOUSHEY IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p.
(IAF PAPER 85-453)

A brief narrative history of the first Jet Assisted Take-Off tests in the US is given. The tests were conducted by the Army Air Corps in 1941 to study the capabilities of rockets. A photograph of the Ercoup jet-assisted test aircraft is provided. I.H.

**N86-14213*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**EMERGING AEROSPACE TECHNOLOGIES**
W. F. BALLHAUS, JR. and L. A. MILOV Sep. 1985 16 p refs
(NASA-TM-86837; REPT-85409; NAS 1.15:86837) Avail: NTIS HC A02/MF A01 CSCL 05D

The United States Government has a long history of promoting the advancement of technology to strengthen the economy and national defense. An example is NASA, which was formed in 1958 to establish and maintain U.S. space technology leadership. This leadership has resulted in technological benefits to many fields and the establishment of new commercial industries, such as satellite communications. Currently, NASA's leading technology development at Ames Research Center includes the Tilt Rotor XV-15, which provides the versatility of a helicopter with the speed of a turboprop aircraft; the Numerical Aerodynamic Simulator, which is pushing the state of the art in advanced computational mathematics and computer simulation; and the Advanced Automation and Robotics programs, which will improve all areas of space development as well as life on Earth. Private industry is involved in maintaining technological leadership through NASA's Commercial Use of Space Program, which provides for synergistic relationships among government, industry, and academia. The plan for a space station by 1992 has framed much of NASA's future goals and has provided new areas of opportunity for both domestic space technology and leadership improvement of life on Earth. Author

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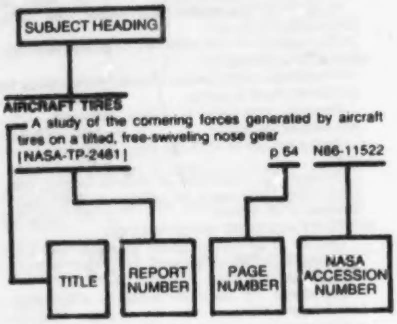

The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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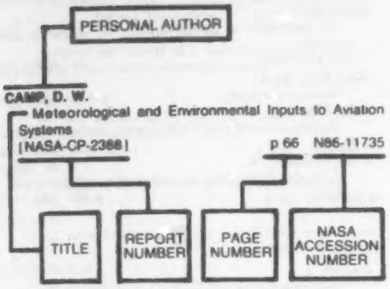
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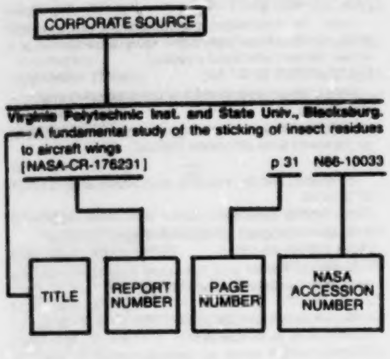
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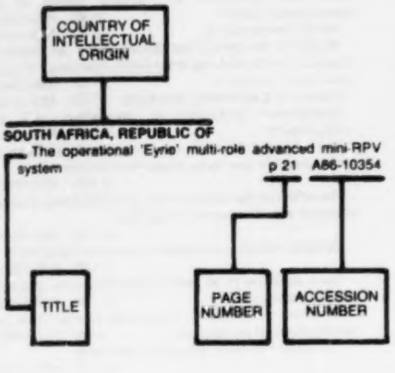
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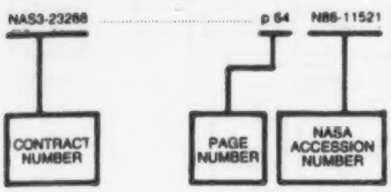

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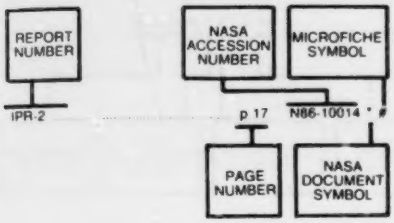

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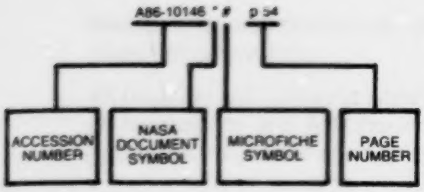

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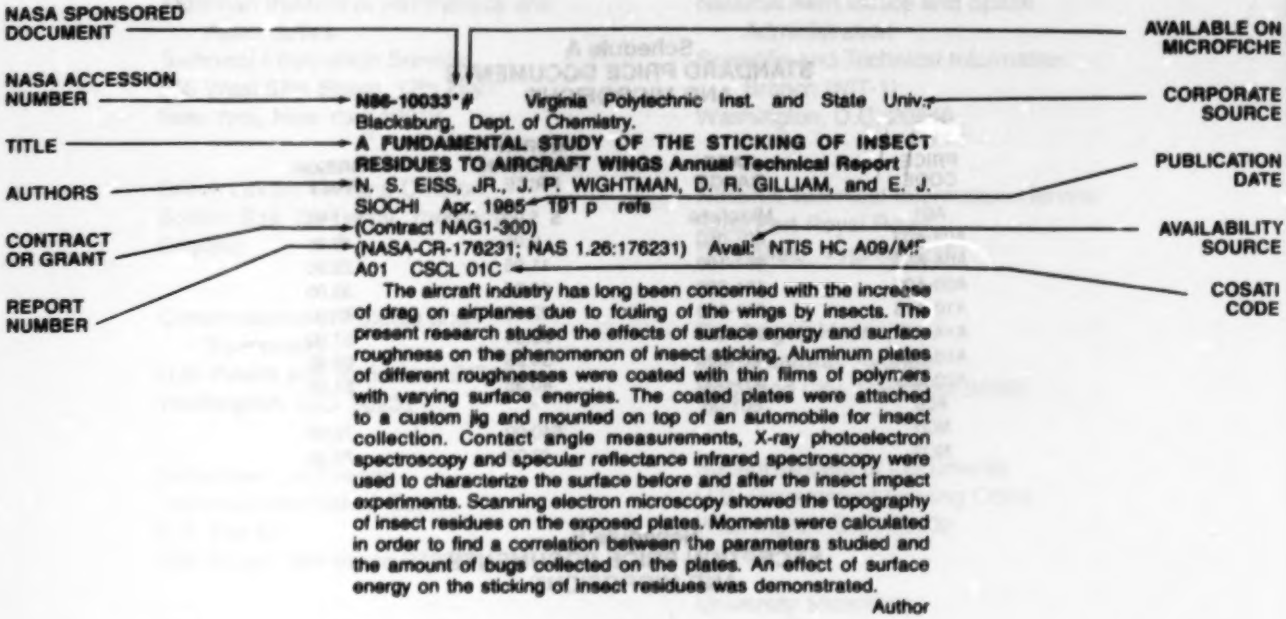
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**N86-10033*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.

**A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**

N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs

(Contract NAG1-300)

(NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

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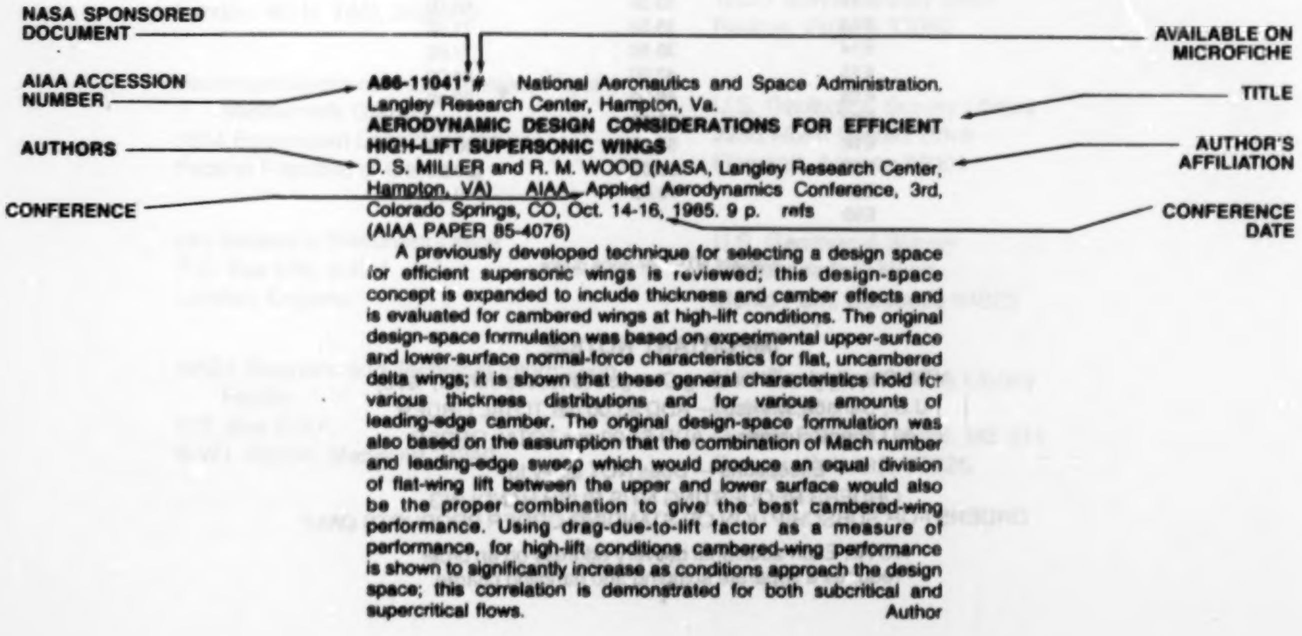
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**A86-11041*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS**

D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs

(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 428 reports, journal articles, and other documents originally announced in March 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

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# AERONAUTICAL ENGINEERING

## A Continuing Bibliography (Suppl. 199)

APRIL 1986

## 01

## AERONAUTICS (GENERAL)

**A86-16207**

**PARTS INTEGRATION - ADVANTAGES AND PROBLEMS**

K. B. ARMSTRONG (British Airways, Hounslow, England) IN: Carbon fibres: Uses and prospects; Proceedings of the Third International Conference, London, England, October 8-10, 1985 . London, Plastics and Rubber Institute, 1985, p. 15/1-15/6.

In the present consideration of comparative advantages and dissadvantages governed by the degree to which composite structure elements are integrated, with a view to size and cost, advantages are noted to accrue primarily to manufacturers, rather than to users. Larger structural elements are more difficult to remove when in need of repair; such large, expensive elements are, moreover, less likely to be held in stock for replacement. Cold-setting repair adhesives must be developed in order to obviate removal. O.C.

**A86-16855**

**AN AIRCRAFT MAINTENANCE AND REPAIR STRATEGY USING A TEST AND DIAGNOSTIC SYSTEM [STRATEGIE OBSLUHY A UDRZBY LETOUNU S VYUZITIM KONTROLNE-DIAGNOSTICKEHO SYSTEMU]**

B. SVOBODA Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 77-81. In Czech. refs

An approach to the definition of an aircraft maintenance and repair strategy using an automatic test and diagnostic system is developed which involves determining the operation cycle of an aircraft, working out a maintenance schedule, and describing briefly the types of jobs to be done during maintenance. The required labor for the maintenance of a third-generation aircraft, now being designed, is estimated in man-hours. Second- and third-generation aircraft are then compared in terms of maintenance requirements. V.L.

**A86-16859**

**A STUDY OF THE OPERATING CONDITION OF AIRCRAFT FROM THE RECORDINGS OF THE ONBOARD RECORDING EQUIPMENT [SLEDOVANI TECHNICKEHO STAVU LETOUNU ZE ZAZNAMU PALUBNIHO REGISTRACNIHO ZARIZENI]**

P. ROZTOCIL Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 97-99. In Czech.

Timely information on the operating condition of practice jet aircraft, available as soon as possible after the flight, is essential for improving the efficiency of aircraft maintenance and reducing the probability of emergency situations. The approach described here includes quick and in-depth localized analyses using a computer, the in-depth analysis being performed only in case of malfunctions. This is combined with a long-term statistic analysis of flight information. V.L.

**A86-16860**

**PROCESSING OF AIRBORNE TAPE RECORDINGS WITH THE AID OF USER PROGRAMS FOR MONITORING THE TECHNICAL CONDITION OF AIRCRAFT [ZPRACOVANI MAGNETICKEHO PALUBNIHO ZAZNAMU UZIVATELSKYMI PROGRAMY PRO KONTROLU TECHNICKEHO STAVU LETADLA]**

J. VORACKOVA Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 101-103. In Czech.

**A86-16861**

**USING DIAGNOSTIC SYSTEMS TO COLLECT DATA ON THE RELIABILITY OF AIRCRAFT [VYUZITI DIAGNOSTICKYCH SYSTEMU PRO SBER DAT O SPOLEHLIVOSTI LETECKE TECHNIKY]**

M. JELINEK Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 105-107. In Czech. refs

Diagnostic systems relying on the onboard recording of diagnostic parameters can also be used for collecting data on malfunctions occurring during flight operations. By expanding the disk memory of the ground-based flight-data processing system and by using special software, it is possible to provide the user with comprehensive reliability data for particular types of aircraft. The need for developing a standardized coding system is emphasized. V.L.

**A86-17379**

**COMPOSITE TAIL SECTION OFFERS SUPERIOR PERFORMANCE**

J. TUTKA (U.S. Army, Aviation Systems Command, St. Louis, MO) ManTech Journal, vol. 10, no. 3, 1985, p. 33-40. Army-supported research.

The development of a helicopter tail section using a wet filament winding cocure process is discussed. The optimization of the design in order to produce a light weight, low cost tail section with increased reliability is examined. The tailboom, vertical tail, and stabilator which compose the tail section are described. The wet filament cocuring manufacturing process, which begins with a single circuit helical pattern, then a two circuit pattern, multiple circuit patterns, and finally hoop or circumferential windings, is diagrammatically explained. The weight analysis, reliability assessment, nondestructive evaluation of components, ballastic vulnerability testing, and the evaluation of the FM antenna are conducted. A weight reduction of 71 pounds and a cost savings of $41,000.00 is achieved with this manufacturing process. I.F.

**A86-17380**

**PULTRUSION USED TO FABRICATE TAIL ROTOR SPAR**

H. REDICK (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) ManTech Journal, vol. 10, no. 3, 1985, p. 41-48. Army-supported research.

The development of a pultrusion manufacturing process for cost-effective fabrication of flexbeam spars is examined. Two design concepts are proposed; concept one is a build-up from fully cured plies with high design risk because not all the fibers are continuous, and concept two uses partially cured unidirectional graphite/epoxy pultrusion with a low design risk. The subscale and full-size testing of both design concepts is described; the concept two design was selected for fabrication. A cost comparison of the two design concepts with conventional spar manufacturing techniques reveals a significant savings is possible with the new manufacturing process; however, actual flight evaluation of the spar resulted in increased load requirements and reduced the cost-effectiveness of the pultrusion process. I.F.

**A86-17434**

### STEALTH

B. SWEETMAN Interavia (ISSN 0020-5168), vol. 40, Nov. 1985, p. 1217-1219.

In the present speculative discussion of 'stealth' or reduced observability technology currently being developed in high security facilities by U.S. military aircraft manufacturers, attention is given to historical trends in the measures used to reduce thermal IR emissions and radar reflectivity in such aircraft as the U-2 and SR-71. The importance of radar-absorbing materials and blended wing-fuselage surface contours is noted. 'Flying wing' configurations are suggested to be the most likely basis for the Advanced Technology Bomber that is to supplement the B-1B bomber force. Stealth-related features of proposed configurations for the U.S. Air Force's Advanced Tactical Fighter program are discussed. O.C.

**A86-18413**

### MAINTAINABLE DEMONSTRATION FOR ARMY HELICOPTERS

R. L. POWELL and W. S. MCDONALD (U.S. Army Aviation Systems Command, St. Louis, MO) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 4 p.

Maintainability is an aircraft system parameter that has become critical in the wake of the increasing complexity and cost that accrue to technological advancement; it must accordingly be given a prominent place in design considerations. Helicopter features prominently involved in maintainability are test points, accessibility of components, control systems, test equipment, tools, data displays, maintenance manuals, checklists, safety considerations, and system quality checks. The development of maintainability demonstration procedures should begin no later than the beginning of full scale development for a given system. O.C.

**A86-18417**

### OBSERVATIONS ON HELICOPTER INTEGRATED SYSTEM TESTING BASED ON F/A-18 EXPERIENCES

W. E. MCCLURE (McDonnell Aircraft Co., St. Louis, MO) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 14 p.

The U.S. Navy's F/A-18 Hornet Strike-Fighter development program preceded the U.S. Army's new advanced light-helicopter program - the LHX - by ten years. A review of both programs shows that they have many similarities. Both involve a significant move forward in systems technology and degrees of integration and automation. Both have similar development schedules. The avionics system for the LHX will closely resemble the F/A-18 except for the advances in technology. The F/A-18 developmental test process, the facilities used, and their applicability to advanced systems developments are discussed. Similar approaches and facilities will be required for the successful development of an advanced, highly integrated avionics system like the LHX. Author

**A86-18425**

### THE US ARMY AVIATION FLIGHT ACTIVITY - AN OVERVIEW

A. R. TODD (U.S. Army Aviation Engineering Flight Activity, Edwards AFB, CA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 3 p.

The U.S. Army's Aviation Engineering Flight Activity organization is responsible for flight tests leading to the airworthiness qualification of Army aircraft. Attention is presently given to the 24-year history of this organizatioh, and to the roles it fulfills in testing fabrication, maintenence, instrumentation, and data acquisition/reduction tasks. Emphasis is placed on real time data acquisition systems applicable to questions of performance, flying qualities, climatic conditions, and icing. O.C.

**A86-18430**

### HELICOPTER FATIGUE SPECIALISTS' MEETING, ST. LOUIS, MO, OCTOBER 16-18, 1984, PROCEEDINGS

Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1984, 395 p. For individual items see A86-18431 to A86-18449.

The present conference on helicopter structural fatigue considers generic aspects of delamination in composite materials fatigue, fatigue in thin walled composite tubes, the evaluation of the UH-60A's titanium main rotor hub, full scale fatigue testing of composites, and spectrum load analysis methods for aircraft structures. The AH-64, AV-8B, and SH-2F airframe fatigue test programs are featured, together with damage-tolerant design concepts applicable to dynamic helicopter components. Also discussed are the use of the Service Life Assessment Program for identification of life extension procedures applicable to fatigue-sensitive aircraft components, and damage tolerance in civil helicopter design. O.C.

**A86-18442**

### USE OF A SERVICE LIFE ASSESSMENT PROGRAM (SLAP) FOR IDENTIFYING SERVICE LIFE EXTENSION PROGRAM (SLEP) PROCEDURES FOR FATIGUE SENSITIVE AIRFRAME COMPONENTS

A. MONGILLO, A. MANK, and F. A. CAMARATTA (United Technologies Corp., Airframe Structures Dept., Stratford, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 13-1 to 13-16.

The procedures for conducting a Service Life Assessment Program (SLAP) for fatigue sensitive airframe and landing gear components are presented in this paper. SLAP provides an analytical method for identifying Service Life Extension Program (SLEP) recommendations. SLEP, an effective means of extending the reliable service life of existing military fleet helicopters, is fast becoming an essential alternative to helicopter retirement. To achieve this goal it is imperative that the current service life capability of selected components be established by relying on crack initiation time and crack growth predictions based on current and projected helicopter usage. In this way critical fatigue sensitive components can be identified and replaced or improved to enhance aircraft system safety. Author

**A86-18721**

### THE EMPLOYMENT OF OPERATIVE AIRCRAFT DISPATCHERS [EINSATZ VON OPERATIVEN LUFTFAHRZEUGABFERTIGERN]

J. VIETZE (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-Oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 5, 1985, p. 161-164. In German.

In 1984, investigations were started in the German Democratic Republic regarding the functions of the operative aircraft dispatcher. The considered functions do not represent a new development for the airport Berlin-Schoenefeld. However, requirements arise for the improvement and the qualification of the process-controlling system. These requirements are related to the introduction of more advanced and larger aircraft, the employment of new operational techniques, and an increasing utilization of automation. The structure of the current system for the control of dispatching operations is critically examined, and approaches for the elimination of certain problems are discussed. Attention is given to the fundamental technological concept, personnel and material aspects, the utilization of data transmission by radio, the transitional phase concerning the introduction of the new operative aircraft dispatching services, and the benefits which can be obtained as a result of the proposed changes. G.R.

**A86-18724**
**ASPECTS OF CURRENT INTEREST CONCERNING THE DEVELOPMENT OF WORLD AIR TRAFFIC. II [AKTUELLE ENTWICKLUNGSASPEKTE DES WELTLUFTVERKEHRS. II]**
J. GRENZDOERFER (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-Oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 5, 1985, p. 188-191. In German.

The origin and development of the Soviet airline Aeroflot are discussed, taking into account the great number of passengers using Aeroflot, the huge volume of air cargo, the use of aircraft to support people in remote areas of the Soviet Union, the employment of aircraft in operations related to agriculture and forestry, missions to provide medical aid, remote sensing studies, the utilization of aircraft in construction projects, and the maintenance of scientists conducting research in polar regions. Statistical data regarding the development of world air traffic in 1984, published by the ICAO, are examined, and the competitive situation with respect to current airliners produced in the U.S. and Europe is considered. The causes of aircraft accidents are also evaluated, giving attention to the development of special devices and procedures which will make it possible to avoid accidents and enhance safety. G.R.

**A86-19284**
**DFVLR, ANNUAL REPORT 1984 [DFVLR, JAHRESBERICHT 1984]**
Cologne, West Germany, Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, 1985, 107 p. In German. No individual items are abstracted in this volume.

The research fields considered include air traffic measurement, aircraft technology, turbo propulsion and turbomachinery, nonnuclear energy systems, satellite communication and localization, remote sensing of the earth, space systems, and advanced technologies and technology transfer. Attention is given to the Avionics Flight Evaluation System (AFES), the new adaptive test section for the high-speed wind tunnel at Goettingen, active control technology, the operative range of aircraft, titanium alloys in turbine engines, first operational results of the solar power pilot plant in Southern Spain, and satellite communication for mobile users. Other topics explored are related to the detection of forest disease by remote sensing methods, the results of 'Maus' experiments, and Titan, the deep diving simulator of the Institute for Aerospace Medicine. G.R.

**N86-14215*#** Ecosystems International, Inc., Crofton, Md.
**NASA FLIGHT OPERATIONS REVIEW Final Report**
Aug. 1985 153 p Sponsored by NASA
(NASA-CR-176404; NAS 1.26:176404) Avail: Issuing Activity CSCL 01B

This report is the fourth of a series of independent assessments of the provisions taken by NASA to assure the safety of their aviation operations. The particular review covered by this report concerns aviation operations conducted at the Kennedy Space Center (KSC). These reviews and independent assessments were undertaken as part of an on-going effort to provide NASA management with a qualitative evaluation of the overall organizational structure, administrative policy, and management provisions which dictate the manner in which NASA's aviation operations are conducted. This review was conducted by a group of unbiased aviation experts, selected for their familiarity and experience with aviation flight research and development activity. Recommendations for improvements are provided in this report whenever a significant impact on the present level of safety assurance was judged to be feasible. B.W.

**N86-14216#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**ACTA AERONAUTICA ET ASTRONAUTIC SINICA (SELECTED ARTICLES)**
W. JI, G. DE, A. SUN, Y. WU, and X. YANG 5 Aug. 1985 243 p Transl. into ENGLISH from Hangkong Xuebao (China), v. 5, no. 2, Jun. 1984 p 103-167, 178-192, 200-247
(AD-A158454; FTD-ID(RS)T-1515-84) Avail: NTIS HC A11/MF A01 CSCL 01C

Among the topics discussed in this report are the following: aeroelastic research; scene matching and its application to aerospace electron systems; a kernel function method for computing unsteady load on three-dimensional wings in transonic flow; root locus method and automatic identification of modes in flutter analysis; determination of axis and angle of rotation of retractable landing gear; delta function and generalized tables of thermodynamic properties of combustion products of C sub n H sub m - air system; multi-rate digital flight control system; reconfigurable redundancy management strategy for a triplex DFBW system; an equivalent strength method for optimum design of composite laminates. GRA

**N86-15240#** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
**ACTIVITIES REPORT IN AEROSPACE RESEARCH Annual Report, 1984 [KONZERN-GESCHAEFTSBERICHT 1984]**
Jun. 1985 43 p In GERMAN Original contains color illustrations
Avail: NTIS HC A03/MF A01

Research concerning helicopters, transport aircraft, and airliners, astronautics, and defense are discussed. Energy and process techniques are studied. Author (ESA)

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-16249**
**STATIC AND DYNAMIC PITCH STABILITY OF A BLUNTED CONE WITH FORWARD FACING AERODYNAMIC SPIKE IN HYPERSONIC FLOW**
G. R. HUTT and R. A. EAST (Southampton, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Oct. 1985, p. 307-314. Research supported by the Ministry of Defence (Procurement Executive). refs

This paper presents experimental data highlighting the effects of a forward facing aerodynamic spike on the pitch stability of a blunted cone in hypersonic flow. Spike length and angle of attack variations on stability derivatives are described. Suitable application of the inviscid embedded Newtonian pitch stability prediction technique shows how the influence of spike aerodynamics may be successfully modeled. The paper extends the knowledge of aerodynamic spike flow effects, which have to date concentrated on aerodynamic drag reduction qualities at zero degrees angle of attack. Author

**A86-16250**
**ON THE EFFECTS OF BOUNDARY-LAYER TRANSITION ON A CYLINDRICAL AFTERBODY AT INCIDENCE IN LOW-SPEED FLOW**
D. I. A. POLL (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Oct. 1985, p. 315-327. Research supported by the Ministry of Defence (Procurement Executive). refs

The experimentally observed changes in the location of boundary layer separation on the cylindrical afterbody of a tangent-ogive-cylinder, placed at incidence in a uniform flow, are related to the phenomenon of laminar-turbulent transition. Existing knowledge of the transition mechanisms which operate in general, three-dimensional, boundary layers, is described and simple prediction criteria are derived for this configuration. These criteria are compared with the currently available empirical methods for the prediction of critical Reynolds numbers for such flows. It is demonstrated that the methods which have been published to date are incomplete and the accompanying analyses are based upon superficial and erroneous physical arguments. The implications of boundary layer transition on the normal forces generated by a cylindrical afterbody are also discussed. Finally, the possibility of using transition fixing to establish 'high Reynolds number' separated flows in 'low Reynolds number' wind-tunnel facilities is briefly considered. Author

**A86-16301*** Notre Dame Univ., Ind.

**CONFERENCE ON LOW REYNOLDS NUMBER AIRFOIL AERODYNAMICS, NOTRE DAME, IN, JUNE 16-18, 1985, PROCEEDINGS**

T. J. MUELLER, ED. (Notre Dame, University, IN) Conference sponsored by NASA, U.S. Navy, and University of Notre Dame. Notre Dame, IN, University of Notre Dame, 1985, 354 p. For individual items see A86-16302 to A86-16324.
(Contract NASA ORDER L-77177-B; N00014-85-G-0123)

Topics of interest in the design, flow modeling and visualization, and turbulence and flow separation effects for low Reynolds number (Re) airfoils are discussed. Design methods are presented for Re from 50,000-500,000, including a viscous-inviscid coupling method and by using a constrained pitching moment. The effects of pressure gradients, unsteady viscous aerodynamics and separation bubbles are investigated, with particular note made of factors which most influence the size and location of separation bubbles and control their effects. Attention is also given to experimentation with low Re airfoils and to numerical models of symmetry breaking and lift hysteresis from separation. Both steady and unsteady flow experiments are reviewed, with the trials having been held in wind tunnels and the free atmosphere. The topics discussed are of interest to designers of RPVs, high altitude aircraft, sailplanes, ultralights and wind turbines. M.S.K.

**A86-16302*#** Stuttgart Univ. (West Germany).

**AIRFOIL DESIGN FOR REYNOLDS NUMBERS BETWEEN 50,000 AND 500,000**

R. EPPLER (Stuttgart, Universitaet, West Germany) and D. M. SOMERS (NASA, Langley Research Center, Hampton, VA) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 1-14. refs

The design of airfoils for flows with Re of 50,000-500,000 requires consideration of laminar separation bubbles. A design approach is discussed which specifies the angle of attack at which the potential flow velocity is to be constant at each segment of the airfoil. The velocity gradient is controlled by introducing a pressure recovery function at the trailing edge. Boundary layer stability decreases with rising Re, although an upper Re value can be identified, below which the boundary layer will be stable. Adverse pressure gradients are associated with the shape parameter of the velocity profile, whose rise in value decreases stability. Transition displays similar relationships to the shape parameter. The most frequent feature of separation is the appearance of a separation bubble. M.S.K.

**A86-16303#**

**LOW REYNOLDS NUMBER AIRFOIL DESIGN**

M. D. MAUGHMER (Pennsylvania State University, University Park) and M. S. SELIG (Princeton University, NJ) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 15-26. refs

Attempts at developing techniques for characterizing velocity profile effects on a low Re airfoil are explored. The low Re of the flow can cause uncontrollable factors in the free stream, e.g., turbulence, to cause separation beyond the control of the designer. Experimental data have shown that hysteresis effects occur in lift and drag at Re under 200,000 in stall conditions. The separation effects which cause the hysteresis can be avoided by the use of turbulators which induce velocity distributions that do not allow separation bubbles to form. Short and long separation bubbles are also affected by the leading edge and upper surface shapes of the airfoil. Airfoil shapes generated with the Eppler and Somers code and with finite trailing edge pressure gradients are discussed. The former was for sailplane competition. M.S.K.

**A86-16304#**

**AIRFOIL DESIGN AT LOW REYNOLDS NUMBER WITH CONSTRAINED PITCHING MOMENT**

R. H. LIEBECK and P. P. CAMACHO (Douglas Aircraft Co., Long Beach, CA) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 27-51.

The design principles applied and the wind tunnel data gathered for the performance of two airfoils intended for use in low Re regimes are discussed. The lift coefficient range desired was 0.5-1.5 and the maximum lift coefficient was to be 1.8. One airfoil, the LNV109A, was to have a pitching moment constrained to -0.05 and be thicker and have a larger negative pitching moment than the other airfoil, the LA203A. The LNV109A was designed, following tests with the Wortman FX63-137 airfoil, to incorporate a Stratford recovery distribution and mild aft-loading. The airfoils were instrumented with numerous surface pressure taps and a wake rake and tested up to 195 mph at four Re values from 250,000-650,000. Some trials were run with transition strips attached to the airfoils' upper surfaces. The LA203A did not have a transition problem, although the lift coefficient was 1.7 instead of the desired 1.8. The LNV109A experienced a drag penalty, attributable to the presence of a separation bubble, at the lower Re. M.S.K.

**A86-16305#**

**A VISCOUS-INVISCID COUPLING METHOD FOR THE DESIGN OF LOW REYNOLDS NUMBER AIRFOIL SECTIONS**

A. A. HASSAN (Arizona State University, Tempe) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 53-63. refs

An inviscid-viscous hybrid model is presented for designing low Re airfoils. The inverse design algorithm (IDA) combines a direct computational approach for selecting the aerodynamics of an airfoil and an inverse approach for the expected pressure distributions (PD). IDA includes a conformal transformation of the semi-infinite, two-sheeted Riemann hodograph free-surface representation of the airfoil into a unit circle. A target pressure distribution serves as input at selected Mach numbers. The full stream function equation is solved with second-order accurate direct solver. A Neumann boundary condition satisfies the tangency condition for the unit circle conformal mapping, which is solved using the FLO6 finite difference algorithm. Corrections are defined for boundary layer effects such as the displacement thickness, which is computed at every streamwise computational node. The model is fully automated but requires further work to reduce the required computational effort and to handle separation conditions. M.S.K.

**A86-16306#**

**EFFECT OF PRESSURE GRADIENTS ON THE GROWTH OF SUBHARMONIC DISTURBANCES IN BOUNDARY LAYERS**

T. HERBERT and F. P. BERTOLOTTI (Virginia Polytechnic Institute and State University, Blacksburg) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 65-76. refs
(Contract N0014-84-K-0093)

Spatial growth is incorporated in a model of secondary instability occurring around low Re airfoils. Governing equations are defined for the periodic basic flow over a semi-infinite plate at a given angle of attack. Expressions are defined for the boundary layer stream function, the Falkner-Skan equation and the Tollmein-Schlichting waves which appear as primary disturbances. A secondary disturbance is superimposed on the basic flow model and entered into the Navier-Stokes equations. Modifications result in a series of linear differential equations from which the subharmonic mode can be extracted, reformed into a Fourier series, and combined to model the secondary disturbances. The model is extended to describe temporal and spatial growth of both primary and secondary modes. A stability analysis for an FX-63-137 airfoil, when compared with experimental data, gives accurate lift and drag values but fails to generate acceptable velocity profiles. Techniques which will increase the accuracy of the computations and permit descriptions of the self-sustained growth of secondary modes are discussed. M.S.K.

**A86-16307#**

**COMPUTATIONAL AND THEORETICAL STUDIES OF UNSTEADY VISCOUS AERODYNAMICS**

J. C. WU (Georgia Institute of Technology, Atlanta) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 77-88. refs
(Contract AF-AFOSR-82-0108; DAAG29-82-K-0094)

A coordinated theoretical and computational approach for analyzing unsteady aerodynamics of viscous fluids is reviewed. This approach permits aerodynamic computations to be confined to the viscous region of the flow and aerodynamic analyses to be carried out with a knowledge of the viscous region of the flow only. The approach also permits the individual flow zones contribution to unsteady aerodynamic load to be identivied and their relative importance evaluated. This approach is based on viscous flow equations. For aerodynamic flows in the absence of appreciable recirculating regions, the approach produces classical theories of aerodynamics and panel-vortex lattice computation procedures. The approach is ideally-suited for aerodynamic analyses of unsteady flows containing massive separated regions. Author

**A86-16308#**

**RESEARCH ON LAMINAR SEPARATION BUBBLES AT DELFT UNIVERSITY OF TECHNOLOGY IN RELATION TO LOW REYNOLDS NUMBER AIRFOIL AERODYNAMICS**

J. L. VAN INGEN and L. M. M. BOERMANS (Delft, Technische Hogeschool, Netherlands) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 89-124. DFVLR-supported research. refs

An overview is presented of research at Delft University of Technology on laminar separation bubbles in relation to low Reynolds number airfoil aerodynamics. Results of flow visualization studies are used to define an empirical relation for the angle at which the separation streamline leaves the wall. The e(n) transition prediction method is extended to separated flows. It is shown that a simple bursting criterion is provided by Stratford's limiting pressure distribution for a zero skin friction turbulent boundary layer. A universal description of the laminar part of the bubble is proposed, resulting in a simple bubble prediction method. The effect of tripping devices for decreasing the adverse effect of the bubble on drag is discussed. Finally, some results of low Reynolds number airfoil tests are reported. Author

**A86-16309*#** Notre Dame Univ., Ind.

**AN ANALYSIS OF A SEPARATION BUBBLE TRANSITION CRITERION AT LOW REYNOLDS NUMBERS**

G. S. SCHMIDT, M. M. OMEARA, and T. J. MUELLER (Notre Dame, University, IN) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 125-136. Research sponsored by the University of Notre Dame. refs
(Contract NSG-1419)

Factors which influence the criterion governing the length of the laminar region of a separation bubble on an airfoil at low Re were investigated. The criterion is the onset of separation when a critical Re value is surpassed. Wind tunnel data were gathered for the flow around a NACA 66(3)-018 airfoil at Re from 50,000-200,000. The data were taken with either hot-wire anemometers or pressure taps. The value of the critical Re was influenced by the chord Re, the angle of attack and the level of turbulence in the free stream. However, the turbulence levels examined, up to 0.184 percent, did not greatly affect the critical Re. Further characterizations of the effects of the three factors on the critical Re are necessary before the important features of separation bubbles can be identified with an acceptable level of certainty. M.S.K.

**A86-16310#**

**THEORETICAL AND EXPERIMENTAL STUDY OF LOW REYNOLDS NUMBER TRANSITIONAL SEPARATION BUBBLES**

C. GLEYZES, J. COUSTEIX, and J. L. BONNET (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 137-152. refs

A review of selected work on transitional separation bubbles is presented. An experimental study in two-dimensional flows provided information about the effects of separation bubbles on the flow on the upper surface of an airfoil at low Reynolds number. A detailed study of the transition mechanisms was also performed, and boundary layer surveys permitted validation of the calculation method. The method is based on an inverse boundary layer calculation associated with a local viscous-inviscid interaction. Transition being a critical problem, an adequate criterion was developed. Extension of the model to three-dimensional infinite swept wing configuration is in progress. Author

**A86-16312*#** Virginia Univ., Charlottesville.

**SEPARATION BUBBLE BEHAVIOR FOR A NACA 23009 AIRFOIL**

S. S. FISHER (Virginia, University, Charlottesville), J. D. ABBITT, and G. W. OLEARY IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Da[illegible] University of Notre Dame, 1985, p. 169-181. NASA-suppo[illegible]search. refs

Results are reported of experiments with smoke-wire flow visualization applied to characterizing the conditions conducive to formation of a separation bubble on an airfoil in low Re flow. An airfoil was used which spanned the test channel of the wind tunnel designed for low turbulence and noise. A wire coated with mineral oil was stretched across the channel upstream of the airfoil and heated. The smoke it gave off was flash-illuminated and photographed with ASA 3000 film. Extending the airfoil over the entire section yielded photographs that gave an essentially two-dimensional perspective. Angles of attack from 0-10 deg were investigated at Re of 33,000, 66,000, 100,000 and 133,000. Sample photographs illustrate the usefulness of the technique and apparatus in the flow regimes examined, particularly when used in conjunction with pressure tap data from the airfoil surface. M.S.K.

**A86-16313#**

**ASPECT RATIO EFFECTS ON THE AERODYNAMICS OF A WORTMANN AIRFOIL AT LOW REYNOLDS NUMBER**

J. F. MARCHMAN, III, A. A. ABTAHI, and V. SUMANTRAN (Virginia Polytechnic Institute and State University, Blacksburg) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 183-193. Research supported by Virginia Polytechnic Institute and State University. refs
(Contract N00014-84-K-0093)

Wind tunnel tests were conducted on a series of wings employing the Wortmann FX-63-137-ESM airfoil to determine the influence of wing aspect ratio on the aerodynamic behavior of that section at low Reynolds numbers. Tests were performed in the six by six foot test section of the Virginia Tech Stability Wind Tunnel at a free stream turbulence level of two one-hundredths of a percent. Tests were conducted at Reynolds numbers between 50,000 and 500,000 with model wing aspect ratios of 4, 6, 8 and 10. Test results showed that aspect ratio influences the size of the low Reynolds number stall hysteresis loop and the range of Reynolds number over which the hysteresis loop exists as well as having the usual effects on the slope of the lift curve and the magnitude of the maximum lift coefficient. Flow visualization tests showed no three dimensional flow patterns at low Reynolds numbers other than the expected wing tip flows. Author

**A86-16314#**

### PERFORMANCE OF FINITE WINGS AT LOW REYNOLDS NUMBERS

W. G. BASTEDO, JR. and T. J. MUELLER (Notre Dame, University, IN) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 195-205. refs
(Contract N00014-83-K-0239)

The performance of three rectangular wings of aspect ratios equal to 5.4, 4.0 and 3.0 were studied at chord Reynolds numbers ranging from 80,000 to 200,000. Each wing utilized the Wortmann FX 63-137 airfoil section, and two-dimensional data for this profile was also obtained. Examination of the data revealed that increasing chord Reynolds number increased performance of the wings and the airfoil, while reducing aspect ratio decreased the lift curve slope and overall performance. This data supported the applicability of simple techniques for predicting wing performance from airfoil data. Author

**A86-16315#**

### AN ENVIRONMENTAL AERODYNAMIC TEST SYSTEM FOR LOW-REYNOLDS-NUMBER APPLICATIONS

H.-T. LIU, E. W. GELLER, and M. COOPER (Flow Industries, Inc., Research and Technology Div., Kent, WA) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 207-218. refs
(Contract N00014-83-C-0764)

A truck-mounted environmental aerodynamic test system (EATS) for testing full-scale low-Re wings or flight-ready RPVs is described. The airfoil or RPV is affixed to a boom to extend it into the flow above the truck cab. The wing or RPV is instrumented with a six-component balance for force and moment data. The truck bed carries a mini-meteorological station, an accelerometer, a pitch/yaw gear, a portable generator, a signal conditioner and a microcomputer. The data are gathered in Re from 150,000-1,000,000 in actual environmental conditions, e.g., gusts, turbulence and rain. Based on a system for glider testing, EATS can be used for examining the two- and three-dimensional aerodynamics of high altitude and low speed aircraft. M.S.K.

**A86-16316#**

### SYMMETRY BREAKING AND LIFT HYSTERESIS ARISING FROM MASSIVE LAMINAR SEPARATION - A STUDY OF MULTIPLE STEADY-STATE SOLUTIONS

H. K. CHENG (Southern California, University, Los Angeles, CA) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 219-233. refs
(Contract N00014-82-K-0315)

An approach is described to studying the inviscid-viscous interaction of the body-scale flow involving massive laminar separation, as a modified airfoil problem through a triple-deck and other compatible structures modelling steady-state Navier-Stokes solutions at high Reynolds number. A recent development of this approach applied to wing sections is summarized. The theory admits open and closed wakes, as well as laminar reattachment on the wing. Steady-state solutions pertaining to open-wake models are studied in detail. Examples of solution bifurcation signifying symmetry breaking, hysteresis and other lift anomalies of the low Reynolds number flows are discussed. D.H.

**A86-16317#**

### COMPUTATIONAL STUDY OF FLOW OVER MILEY AND WORTMANN AIRFOILS

A. P. KOTHARI and J. D. ANDERSON, JR. (Maryland, University, College Park) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 235-254. refs
(Contract N00014-81-K-2037; N00014-84-K-0161)

A computational tool has been developed that calculates viscous 2-D flowfields about airfoils of interest. The program uses a finite difference implicit technique to solve the compressible Navier-Stokes equations. Both purely laminar and transitional turbulent flows are treated. The technique is time-dependent and hence makes it possible to treat the transient flowfields. The technique, which does not require the use of a supercomputer, is a modification of MacCormack's implicit technique to handle the curvilinear, boundary-fitted coordinate system which must be wrapped around the airfoil. D.H.

**A86-16318#**

### EXPERIMENTS ON UNSTEADY FLOWS ABOUT WING SECTIONS

E. KRAUSE, G. EHRHARDT, and B. SCHWEITZER (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 255-267.

Vortex shedding on wing sections due to time-dependent variation of the free stream velocity is being studied experimentally. The aim of the investigation is to obtain information about the details of the flow structure, particularly in the vicinity of the trailing edge, to determine shedding frequencies, range of stability of the vortex street, and extent of the separated region. Measurements will be made of the time-dependent surface pressure distribution as a function of freestream Strouhal number and Reynolds number for accelerated and decelerated flows. Results so far have come from a water table and a water tunnel, but experiments are being set up in an Eiffel tunnel. D.H.

**A86-16319#**

### STREAMWISE AND SPANWISE VORTICAL PATTERNS VISUALIZED OVER AIRFOILS IN UNSTEADY FLOW

F. FINAISH, P. FREYMUTH, and W. BANK (Colorado, University, Boulder) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 269-279. refs
(Contract AF-AFOSR-81-0027)

The relationship between the streamwise and the spanwise developments of vortical patterns over airfoils and the transition to turbulence of those patterns in unsteady flow starting from rest are the main subjects of this paper. To study the relationship between the two modes of visualization and to investigate the effect of the three-dimensional disturbances in the spanwise mode, a complementary illustration of the two modes of visualization for different Reynolds numbers and angles of attack is presented by means of selected photographic frames and sequences. Spanwise visualization of the flow field over airfoils in unsteady flow reveals the development of three-dimensional disturbances, which provide more information about the transitional stages and breakdown into turbulence. Author

**A86-16320#**

### PRELIMINARY EXPERIMENTS IN UNSTEADY FLOW ON AIRFOILS AT LOW REYNOLDS NUMBERS

M. BRENDEL and T. J. MUELLER (Notre Dame, University, IN) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 281-292.
(Contract N00014-83-K-0239)

A program to study the aerodynamic characteristics of airfoils in unsteady flows at low Reynolds numbers has recently been initiated. An experimental facility designed to produce temporal variations in the streamwise velocity of the subsonic wind tunnel is presented. The device features a programmable input, thus allowing many variations of periodic velocity waveforms. A method to suppress higher harmonics present in sinusoidal velocity waveforms is discussed. A preliminary experiment to determine the feasibility of extending steady flow pressure measurement techniques is also presented. The data are preliminary since an independent measurement technique has not been employed to validate results. The value of unsteady pressure distributions to reveal aerodynamic parameters and boundary layer characteristics warrants further work into understanding and improving unsteady pressure measurements. Author

**A86-16322#**

**THE EFFECT OF TRIP WIRE ROUGHNESS ON THE PERFORMANCE OF THE WORTMANN FX 63-137 AIRFOIL AT LOW REYNOLDS NUMBERS**

A. F. HUBER, II and T. J. MUELLER (Notre Dame, University, IN) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 307-322. refs

(Contract N00014-83-K-0239)

An experimental investigation was conducted on the performance and boundary layer characteristics of the Wortmann FX 63-137 airfoil with and without trip wire roughness. Data were obtained through use of a three-component strain gage force balance and static pressure measurement equipment at a test Reynolds number of R(c) = 100,000. Emphasis was placed on determining the effect of trip wire placement and size on such performance parameters as (C sub l/C sub d)max and (C sub l exp 3/2/C sub d)max. Prediction of transition location by the criterion due to Tani (1956) and Gibbings (1959) was found to have limited application. In most cases airfoil performance was degraded, but in some instances minimum drag was reduced and maximum lift to drag ratio increased. Author

**A86-16323#**

**ACOUSTIC AND TURBULENCE INFLUENCE ON LOW-REYNOLDS NUMBER WING PRESSURE DISTRIBUTIONS**

V. SUMANTRAN, Z. SUN, and J. F. MARCHMAN, III (Virginia Polytechnic Institute and State University, Blacksburg) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 323-334. Research supported by the Virginia Polytechnic Institute and State University. refs

(Contract N00014-84-K-0093)

Wind-tunnel tests were conducted in the Virginia Tech 6 ft x 6 ft Stability Wind-Tunnel to determine the influence of free-stream turbulence and acoustic disturbances on low Reynolds number wing aerodynamics. The wing model was based on a FX-63-137-ESM airfoil section. Strain gauge measurements, pressure distribution, and flow visualization studies were conducted in the range of Reynolds numbers from 70,000 to 300,000. Starting with the very clean flow inherent in the wind-tunnel, free-stream turbulence and acoustic disturbance levels in the test-section were increased independently. A distinct alteration of the wing's performance was observed particularly with regard to the stall hysteresis loop which may even be eliminated at very low Reynolds number-high disturbance level conditions. This study also shows clearly the behavior of the laminar separation bubble which contracts and moves forward with increasing angle of attack and determines the manner in which the airfoil stalls. Author

**A86-16324*#** Texas A&M Univ., College Station.

**PROPELLER SLIPSTREAM/WING BOUNDARY LAYER EFFECTS AT LOW REYNOLDS NUMBERS**

S. J. MILEY, R. M. HOWARD (Texas A&M University, College Station), and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) IN: Conference on Low Reynolds Number Airfoil Aerodynamics, Notre Dame, IN, June 16-18, 1985, Proceedings . Notre Dame, IN, University of Notre Dame, 1985, p. 335-349. refs

(Contract NAG1-344)

The effects of propeller slipstream on the wing laminar boundary are being investigated. Hot-wire velocity sensor measurements have been performed in flight and in a wind tunnel. It is shown that the boundary layer cycles between a laminar state and a turbulent state at the propeller blade passage rate. The cyclic length of the turbulent state increases with decreasing laminar stability. Analyses of the time varying velocity profiles show the turbulent state to lie in a transition region between fully laminar and fully turbulent. The observed cyclic boundary layer has characteristics similar to relaminarizing flow and laminar flow with external turbulence. Author

**A86-16352#**

**THE APPLICATION OF LASER ANEMOMETRY TO THE STUDY OF TRANSONIC SHOCK BOUNDARY-LAYER INTERACTIONS**

H. J. SCHAEFER (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: International Symposium on Applications of Laser Anemometry to Fluid Mechanics, 2nd, Lisbon, Portugal, July 2-5, 1984, Proceedings . Lisbon, Instituto Superior Tecnico, 1985, p. 1.3 (4 p.). refs

A laser Doppler anemometer operating in forward scatter was used to study the transonic flow above a supercritical airfoil. The measurements were concentrated upon the region of interaction between shock wave and boundary layer. The experimental results, as expressed by the constant Mach number contours, are compared with the corresponding boundary-layer pressure measurements as well as with a numerical simulation of the flow field. Author

**A86-16371#**

**L.D.A. MEASUREMENTS IN THE TURBULENT NEAR-WAKE OF BLUNT BODIES**

C. BERNER and A. KOENEKE (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: International Symposium on Applications of Laser Anemometry to Fluid Mechanics, 2nd, Lisbon, Portugal, July 2-5, 1984, Proceedings . Lisbon, Instituto Superior Tecnico, 1985, p. 7.1 (6 p.). refs

Turbulence fluctuations have been measured in the immediate near-wake behind three blunt axisymmetric afterbodies, using an ISL blow-down type of [illegible] jet that allows Mach number variations in the entire subsonic range (0.22-0.93 M). A two-color, three-beam LDA system equipped with an argon-ion laser as a light source was employed. A 40 MHz Bragg cell was used for measurements of velocity component distributions and the corresponding fluctuations. It was found that stagnation point location is influenced by model geometry and is a function of Mach number, confirming existing theory (Delery, 1983). At constant Mach number, increases of the boattail angle and length led to decreases in size of the recirculating region. In the recirculating region, maximum velocity on the near-wake centerline was equal to about 35 percent of the free-stream velocity regardless of the Mach number. Turbulence quantities were higher for smaller Mach numbers and lower when the recirculation region was reduced. I.S.

**A86-16387#**

### EXPERIMENTAL ANALYSIS OF TIP VORTEX BY LASER DOPPLER ANEMOMETRY

L. ACCARDO (Centro Esperienze Idrodinamiche Marina Militare, Rome, Italy), A. CENEDESE, and F. CIOFFI (Roma, Universita, Rome, Italy) IN: International Symposium on Applications of Laser Anemometry to Fluid Mechanics, 2nd, Lisbon, Portugal, July 2-5, 1984, Proceedings . Lisbon, Instituto Superior Tecnico, 1985, p. 12.4 (6 p.). refs

The aerodynamic performances of aircraft wings, helicopter rotors, marine propellers, and turbomachines are related to the presence of turbulent boundary layers and vortex sheet formation. The mutual interaction between boundary layers makes three-dimensional the phenomenon. This aspect is particularly evident at the wing/body junction and at the extremity of the wings or blades where tip vortices are formed. By means of laser Doppler anemometry, the velocity field is experimentally analyzed close to the tip in the near wake generated by a symmetrical wing with a rectangular plant. The analysis of experimental results shows that there exists a strong axial current in the core of the tip vortex. A velocity logaritmic trend is formed in the zone where there is interaction between the irrotational flow and the core vortex. Author

**A86-16395**

### MEAN FLOW PROPERTIES MEASURED AROUND AN AEROFOIL CLOSE TO ITS MAXIMUM LIFT

R. C. HASTINGS, K. G. MORETON, and R. CLARK (Royal Aircraft Establishment, Bedford, England) IN: International Symposium on Applications of Laser Anemometry to Fluid Mechanics, 2nd, Lisbon, Portugal, July 2-5, 1984, Proceedings . Lisbon, Instituto Superior Tecnico, 1985, p. 14.1 (6 p.). refs

A description is given of a low-speed wind tunnel experiment to define the flow field around an aerofoil on whose upper surfaces separation is well forward of the trailing edge. Most of the data were obtained with a two-component, photon-correlation, laser Doppler anemometer. Integral properties of the aerofoil boundary layer and wake are presented. Pressure distributions on the aerofoil and on the wind tunnel roof and floor are also given. Author

**A86-16687**

### A METHOD FOR MEASURING PRESSURE DISTRIBUTION BY MEANS OF INDICATING COATINGS [METODIKA IZMERENIIA RASPREDELENIIA DAVLENIIA S POMOSHCH'IU INDIKATORNYKH POKRYTII]

M. M. ARDASHEVA, L. B. NEVSKII, and G. E. PERVUSHIN PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1985, p. 24-30. In Russian. refs

A method is presented whereby pressure distribution is measured by using indicating coatings of organic luminophors whose luminescence is quenched by oxygen molecules. The existing indicating coatings are sensitive to air pressure in the range 1000-100000 Pa; the sensitivity depends on the pressure range and is equal to 600 per Pa in the range 3000-10000 Pa. Results of pressure distribution determinations are presented for a sphere, the plane surface of a half-cone, and a plane plate with a superstructure. V.L.

**A86-16691**

### THE EFFECT OF A SHOCK LAYER ON THE VISCOUS RESISTANCE OF STAR-SHAPED BODIES WITH FLAT SIDE FACES [VLIIANIE UDARNOGO SLOIA NA VIAZKOE SOPROTIVLENIE ZVEZDOOBRAZNYKH TEL S PLOSKIMI BOKOVYMI GRANIAMI]

G. I. SHCHEPANOVSKAIA and V. A. SHCHEPANOVSKII PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1985, p. 105-112. In Russian. refs

An approximate model is proposed for calculating the wave and viscous resistance of star-like configurations in supersonic flow. Flow in the boundary layer is investigated as a function of the conditions existing in external flow. Results of calculations of the resistance of star-shaped configurations are presented for a wide range of parameters, and a comparison is made with experimental data. V.L.

**A86-16784**

### SELF-SIMILAR SUPERSONIC GAS FLOWS THROUGH A PERMEABLE SCREEN [AVTOMODEL'NYE SVERKHZVUKOVYE TECHENIIA GAZA CHEREZ PRONITSAEMYI EKRAN]

S. V. GUVERNIUK and S. A. FESHCHENKO Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), Sept.-Oct. 1985, p. 49-54. In Russian. refs

Steady-state supersonic flow of an ideal gas through a thin permeable screen is analyzed for conical and wedge-shaped screens. The permeable boundary is modeled by a hydrodynamic discontinuity surface, and ordinary differential equations are used to describe gas flow in each of the discontinuity regions. Both the plane and the axisymmetric case are considered, and examples of calculations of flow parameters and screen resistance coefficient are presented. V.L.

**A86-16838#**

### INVESTIGATIONS OF TRANSONIC LUDWIEG TUBES. III - EFFECTS OF PLENUM EXHAUST SYSTEM ON STARTING PROCESS OF TUNNEL TEST SECTION

K. KAGE, M. NAGATAKE (Oita University, Japan), K. MATSUO, and S. KAWAGOE (Kyushu University, Fukuoka, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Sept. 1985, p. 1868-1873.

The starting process in a transonic Ludwieg tube with a downstream valve was investigated experimentally by varying the timing of opening the main and the exhaust valves and varying the location of the orifice. A diagram for different opening times is presented. The choking time at the nozzle throat is found to be independent of differences in the timing of opening when the main valve opens first, but increases in proportion to the difference in timing when the exhaust valve opens first. The choking time at the orifice shows the opposite tendency. The starting time is minimum when the main and exhaust valves start to open simultaneously, and increases as the timing difference increases. When the orifice is downstream of the exhaust valve, the starting time is shorter than when the orifice is upstream of the valve. C.D.

**A86-16851**

### MATHEMATICAL SOLUTION FOR UNSTEADY SUBSONIC FLOW PAST A THIN PROFILE IN A CHANNEL [MATEMATICKE RESENI NESTACIONARNIHO SUBSONICKEHO OBTEKANI TENKEHO PROFILU V KANALU]

K. KOZEL and M. VAVRINCOVA Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1985, p. 7-15. In Czech. refs

Consideration is given to unsteady subsonic flow past a thin profile in a channel formed by parallel walls, where the unsteady conditions are caused by periodic oscillations of the profile as well as by time variations of the inlet Mach number. The fundamental equation is derived; the appropriate differential and difference problems are formulated; and a numerical-solution method is presented. A numerical solution is obtained for a periodically oscillating profile with small oscillations at a constant freestream Mach number. Several cases of time variations of inlet flow are also considered. B.J.

**A86-16867**

### MODEL FOR ANALYTICALLY DESCRIBING EDGE VORTICES [EIN MODELL ZUR ANALYTISCHEN BESCHREIBUNG VON RANDWIRBELN]

R. STAUFENBIEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, Sept.-Oct. 1985, p. 283-293. In German. refs

A modification of the Lamb-Olseen model is used to derive an analytical vortex model with enough free parameters to satisfy the conservation laws. It is shown that simulation results obtained with the single vortex method can be used to determine the free model parameters. The model exhibits good agreement with experimental data, and can describe the rolling up of vortex sheets with substantially arbitrary circulation distribution. Since the rolling up occurs in a few seconds and the aging process sets in after 30 to 50 seconds, numerous vortex effects can be ascertained using this model, using only moderate computer time. C.D.

**A86-17031**

### TURBULENT-BOUNDARY-LAYER DEVELOPMENT IN AN ADVERSE PRESSURE GRADIENT AFTER AN INTERACTION WITH A NORMAL SHOCK WAVE

W. H. SCHOFIELD (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 154, May 1985, p. 43-62. refs

An experimental study has been made of the development of a turbulent boundary layer in an adverse pressure gradient after an interaction with a normal shock wave that was strong enough to separate the boundary layer locally. The pressure gradient applied to the layer was additional to the pressure gradients induced by the shock wave. Measurements were taken for several hundreds of layer thicknesses downstream of the interaction. It is shown that the adverse pressure gradient impressed on the flow downstream of the shock has a major effect on the structure of the interaction region and the growth of the layer through it. Consequently, existing results for interactions without a post-shock pressure gradient should not be used as a model for predicting practical flows, which typically have strong pressure gradients applied downstream of the shock wave. Author

**A86-17055**

### AN EXPERIMENTAL STUDY OF GEOMETRICAL EFFECTS ON THE DRAG AND FLOW FIELD OF TWO BLUFF BODIES SEPARATED BY A GAP

K. KOENIG and A. ROSHKO (California Institute of Technology, Pasadena) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 156, July 1985, p. 167-204. refs
(Contract NSF ENG-75-03694; NSF ENG-77-23541)

This paper describes an experimental investigation of the shielding effects of various disks placed coaxially upstream of an axisymmetric, flat-faced cylinder. Remarkable decrease of the drag of such a system was observed for certain combinations of the basic geometric parameters, namely the diameter and gap ratios. For such optimum shielding the stream surface which separates from the disk reattaches smoothly onto the front edge of the cylinder, in what is close to a 'free-streamline' flow; alternatively, the flow may be viewed as a cavity flow. For the optimum as well as other geometries, flow pictures, pressure distributions and some LDV measurements were also obtained. From these, several flow regimes depending on the gap/diameter parameters were identified. Variations on the axisymmetric disk-cylinder configuration included a hemispherical frontbody, rounding of the front edge of the cylinder and a change from circular to square cross-section. Author

**A86-17059*** Montana State Univ., Bozeman.

### MEAN-FLOW MEASUREMENTS IN A SUPERSONIC THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER

A. DEMETRIADES and G. MCCULLOUGH (Montana State University, Bozeman) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 156, July 1985, p. 401-418. refs
(Contract NAG2-37)

Measurements are presented of the mean flow in a supersonic turbulent boundary layer subjected to a constant weak transverse pressure gradient. The temperature and longitudinal velocity and the axial shear stress were only slightly affected by the three-dimensionality but a clearly defined crossflow component appeared, in the manner suggested by theory and confirmed in earlier experiments. The flow deflection angle and transverse-velocity component achieved a self-preserving form so long as the transverse-pressure gradient remained constant, and both achieved a maximum at the sublayer edge; the deflection angle seemed to decrease again between the latter and the surface. An empirical relation was found between the pressure-gradient strength and the maximum in the crossflow, and the dependence of the latter on distance from the surface was used to test analytical crossflow predictions. The data are in general agreement with Van Den Berg's law of the wall. The data also support the so-called parabolic law following a relaxation distance, especially if inviscid gradients are accounted for, and if the normal coordinate is contracted by the compressibility transformation. Author

**A86-17060**

### VORTICES INCIDENT UPON A LEADING EDGE - INSTANTANEOUS PRESSURE FIELDS

R. KAYKAYOGLU and D. ROCKWELL (Lehigh University, Bethlehem, PA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 156, July 1985, p. 439-461. Research supported by the Stiftung Volkswagenwerk, NSF and Navy. refs

The interaction of a periodic row of vortices with an edge involves a splitting of the incident vorticity field into regions that pass above and below the edge. Major elements of this process are distortion/severing of the incident (primary) vortex, secondary vortex shedding from the tip of the edge, and a 'sweeping' of flow about the tip from the top to the bottom surface. Simultaneous flow visualization and surface pressure measurement furnish a link between these vortex edge interaction mechanisms and the instantaneous pressure fields on the edge. With respect to theoretical simulation of the leading edge pressure field, experimental observations suggest that inviscid modeling should not incorporate a leading edge Kutta condition; a singularity at the tip would be adequately representative. O.C.

**A86-17069**

### TRANSONIC ROTOR FLOW-MEASUREMENT TECHNIQUE USING HOLOGRAPHIC INTERFEROMETRY

J. K. KITTLESON and Y. H. YU (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, Oct. 1985, p. 3-10. refs

Holographic interferometry is used to record interferograms of the flow near a hovering transonic rotor blade. A pulsed ruby laser recorded 40 interferograms with a 2-ft-diam view field near the model rotor-blade tip operating at a tip Mach number of 0.90. This paper presents the experimental procedure and example interferograms recorded in the rotor's tip-path-plane. In addition, a method currently being pursued to obtain quantitative flow information using computer-assisted tomography (CAT) with the holographic interferogram data, is outlined. Author

**A86-17096**

### STRUCTURE OF A SUPERSONIC TURBULENT BOUNDARY LAYER DURING ITS INTERACTION WITH A SHOCK WAVE [STRUKTURA SVERKHZVUKOVOGO TURBULENTNOGO POGRANICHNOGO SLOIA PRI EGO VZAIMODEISTVII SO SKACHKOM UPLOTNENIIA]

M. A. GOLDFELD Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1985, p. 75-82. In Russian. refs

The interaction of a turbulent boundary layer with a shock was studied in a supersonic wind tunnel in order to clarify questions connected with the increasing fill coefficient of the velocity profiles. Data on the development, structure, and asymptotic behavior of the boundary layer beyond the interaction region are obtained in axisymmetric flow for Mach numbers of 2-4 and flow rotation angles of 10-25 deg, with particular attention given to the occurrence of separated flow. The data confirm the increase in the fill coefficient beyond the shock as well as a significant increase in the surface friction. B.J.

**A86-17098**

**SUPERCRITICAL MODE OF THE NONLINEAR INTERACTION OF SUBSONIC AND SUPERSONIC INVISCID JETS IN A TWO-DIMENSIONAL CHANNEL [O ZAKRITICHESKOM REZHIME NELINEINOGO VZAIMODEISTVIIA DOZVUKOVOI I SVERKHZVUKOVOI NEVIAZKIKH STRUI V PLOSKOM KANALE]**

D. O. LYZHIN, T. V. TITOVSKAIA, and V. N. TRIGUB Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1985, p. 156-160. In Russian. refs

The nonlinear problem concerning the supercritical mode of the interaction between subsonic and supersonic inviscid jets in a two-dimensional channel is analyzed theoretically with particular attention given to the propagation of small pressure perturbations. A numerical analysis is made of the form of the streamline separating two jets whose nonlinear perturbations have an oscillatory character. The oscillation amplitude is investigated as a function of the similarity parameter, i.e., the integrated characteristic of the unperturbed-flow profile. B.J.

**A86-17129#**

**MULTIPLE DUCTED STREAMS WITH A PERIODIC OR A STEADY SUPERSONIC DRIVER FLOW**

H. L. PETRIE (U.S. Army, Missile Laboratory, Redstone Arsenal, AL), A. L. ADDY, and J. C. DUTTON (Illinois, University, Urbana) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1851, 1852. Abridged. Previously cited in issue 06, p. 710, Accession no. A84-18042. refs
(Contract DAAG29-76-G-0200)

**A86-17131*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A THEORETICAL BASIS FOR EXTENDING SURFACE-PANELING METHODS TO TRANSONIC FLOW**

L. L. ERICKSON and S. M. STRANDE (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1860-1867. refs

The surface integral terms in Green's third identity are often used to solve the Prandtl-Glauert (linear potential-flow) equation with panel methods. This can be done, as in the PAN AIR code, for either subsonic or supersonic flow about complete aircraft. The extension to transonic flow is suggested by the volume integral terms of Green's third identity. The mathematical basis for this extension, without the use of body-fitted grids, is presented. Supercritical transonic results computed from a two-dimensional transonic PAN AIR research code demonstrate the method. Author

**A86-17132#**

**FREESTREAM TURBULENCE EFFECTS ON WAKE PROPERTIES OF A FLAT PLATE AT AN INCIDENCE**

S. PAL (New York City, Dept. of Environmental Protection, NY) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1868-1871. refs

The effect of freestream turbulence on the characteristics of a turbulent wake developed from the trailing edge of a flat plate at angles of attack of -3, 0, and 6 deg is discussed. Correlations based on analytical and experimental considerations are developed to predict the mean characteristics of a turbulent wake at an incidence in the freestream turbulence environment. The analytical approach is based on the Navier-Stokes mean-momentum and continuity equation. The experimentation was carried out in a subsonic wind tunnel using cross-wire anemometry. Experimental data of the flat plate at three incidences and three turbulence levels (0.40, 5.23, and 7.23 percent) from self-similarity considerations are presented to predict the semiempirical correlations for the wake velocity defect, length scale, wake velocity profile, shape factor, and eddy viscosity. The effect of pressure gradient on various parameters is also discussed. It is concluded that the wake velocity defect and shape factor decrease while the length scale and eddy viscosity increase when there is an increase in freestream turbulence. Author

**A86-17134#**

**A TRANSONIC WING-BODY FLOWFIELD CALCULATION WITH IMPROVED GRID TOPOLOGY**

L. T. CHEN, J. C. VASSBERG, and C. C. PEAVEY (Douglas Aircraft Co., Long Beach, CA) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1877-1884. Research supported by the McDonnell Douglas Corp. Previously cited in issue 21, p. 2988, Accession no. A84-44196. refs

**A86-17135*#** Rutgers Univ., New Brunswick, N. J.

**CALCULATION OF THREE-DIMENSIONAL SHOCK/TURBULENT BOUNDARY-LAYER INTERACTION GENERATED BY SHARP FIN**

D. D. KNIGHT (Rutgers University, New Brunswick, NJ) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1885-1891. NASA-sponsored research. Previously cited in issue 17, p. 2424, Accession no. A84-37971. refs
(Contract AF-AFOSR-82-0040)

**A86-17149#**

**VORTEX-FITTED POTENTIAL AND VORTEX-CAPTURED EULER SOLUTION FOR LEADING-EDGE VORTEX FLOW**

H. W. M. HOEIJMAKERS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) and A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1983-1985. Previously cited in issue 21, p. 2989, Accession no. A84-44200. refs

**A86-17150#**

**THREE-DIMENSIONAL SOLUTIONS TO THE EULER EQUATIONS WITH ONE MILLION GRID POINTS**

A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1986, 1987. refs

Three-dimensional solutions to the Euler equations for flow around aircraft wings were computed using standard and dense-size meshes. It was found that the flowfield around a trapezoidal wing like the ONERA M6 wing (freestream M = 0.84; alpha = 3.06 deg) can be accurately represented on a standard-size mesh of about 50,000 grid points. However, for wings of low-aspect ratio, like the subsonic (freestream M = 0.7; alpha = 15 deg) and supersonic (freestream M = 1.5; alpha = 15 deg) Dillner delta wings, a much denser grid of up to a million grid points is required to describe the structure of the vortex flow interacting with the shock waves. I.S.

**A86-17627#**

**SOLUTION OF THE EULER EQUATIONS - EXPLICIT SCHEMES ACCELERATION BY A MULTIGRID METHOD**

V. COUAILLIER (ONERA, Chatillon-sous-Bagneux, France) (Gesellschaft fuer angewandte Mathematik und Mechanik, European Conference on Multigrid Methods, 2nd, Cologne, West Germany, Oct. 1-4, 1985) ONERA, TP, no. 1985-129, 1985, 21 p. refs
(ONERA, TP NO. 1985-129)

A one-dimensional multigrid approach is presented for obtaining explicit solutions for the steady Euler equations expressed in time-marching hyperbolic form. The energy equation is replaced by a Bernoulli relation and the equations are discretized using a Lax-Wendroff scheme for both the time and space components. A linearized stability analysis based on a Fourier analysis is introduced to reduce the computational efforts required at each time step in order to accelerate the convergence of the solution on two coarse grids. An accompanying residual equation is shown to vanish when convergence is achieved, thereby enhancing the accuracy of the method. The results of sample calculations for channel flow, transonic flow, subsonic flow and flows past an airfoil and in a transonic compressor cascade are provided. M.S.K.

**A86-17636#**

### EXPERIMENTAL INVESTIGATION OF THREE DIMENSIONAL SEPARATION ON AN ELLIPSOID-CYLINDER BODY AT INCIDENCE

R. L. SCHMITT and B. P. G. CHANETZ (ONERA, Chatillon-sous-Bagneux, France) AIAA, Fluid Dynamics, Plasma Dynamics, and Laser Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs
(AIAA PAPER 85-1686)

An ellipsoid-cylinder model is used for the experimental study of the incompressible turbulent three-dimensional separation which is associated with a vortex formation. The model consists of an oblate half-ellipsoid with a cylindrical extension terminated by a flat base inclined at 45 deg with respect to the model axis, to stabilize the separation on the rear part of the model. The wind tunnel tests are performed for free stream velocities Vo up to 70 m/s and model angles of attack alpha from 0 to 40 deg. Surface flow visualizations and wall pressure measurements permit to select a particularly interesting configuration corresponding to Vo = 50 m/s and alpha = 30 deg for which the three-dimensional separation occurs on the cylindrical part of the model. The separated region, and in particular the vortex emerging from the boundary layer, is first explored by using a five hole pressure probe. The three-directional laser Doppler velocimetry is used as a second measurement technique to determine the mean velocity field and the components of the Reynolds stress tensor. The influence of the sample size on the uncertainty affecting the statistical values is examined. Regarding the velocity field, the two measurement techniques give results in good agreement. Author

**A86-17653**

### FALSE DIFFUSION IN THREE-DIMENSIONAL FLOW CALCULATIONS

A. O. DEMUREN (Karlsruhe, Universitaet, West Germany) Computers and Fluids (ISSN 0045-7930), vol. 13, no. 4, 1985, p. 411-419. refs

This paper presents the derivation of the three principal components of the false or numerical diffusivities which result from the use of first-order upwind difference schemes in the calculation of steady three-dimensional flows. The effects of the false diffusion are illustrated by comparison of the first-order calculations with those with a higher-order scheme and experimental data, for the flow of a row of turbulent jets issuing at right angles to a nearly uniform cross-stream. The adverse effect of the false diffusivities in suppressing the physics of the flow is shown. Author

**A86-17654*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### A COMPARATIVE STUDY OF THE PARABOLIZED NAVIER-STOKES CODE USING VARIOUS GRID-GENERATION TECHNIQUES

U. K. KAUL and D. S. CHAUSSEE (NASA, Ames Research Center, Moffett Field, CA) Computers and Fluids (ISSN 0045-7930), vol. 13, no. 4, 1985, p. 421-441. refs

The parabolized Navier-Stokes (PNS) equations are used to calculate the flow-field characteristics about the hypersonic research aircraft X-24C. A comparison of the results obtained using elliptic, hyperbolic and algebraic grid generators is presented. The outer bow shock is treated as a sharp discontinuity, and the discontinuities within the shock layer are captured. Surface pressures and heat-transfer results at angles of attack of 6 deg and 20 deg, obtained using the three grid generators, are compared. The PNS equations are marched downstream over the body in both Cartesian and cylindrical base coordinate systems, and the results are compared. A robust marching procedure is demonstrated by successfully using large marching-step sizes with the implicit shock fitting procedure. A correlation is found between the marching-step size, Reynolds number and the angle of attack at fixed values of smoothing and stability coefficients for the marching scheme. Author

**A86-17738**

### ON A WEAK SOLUTION FOR A TRANSONIC FLOW PROBLEM

C. S. MORAWETZ (New York University, NY) Communications on Pure and Applied Mathematics (ISSN 0010-3640), vol. 38, Nov. 1985, p. 797-817. refs
(Contract N00014-85-K-0195)

The existence of weak solutions for steady state two-dimensional inviscid irrotational compressible flow in an infinitely long channel or in the exterior of an airfoil given the speed upstream at infinity is demonstrated. A weak existence theorem for such a flow, in which shocks arise when the fluid attains a certain speed, is established by adding an artificial viscosity. A new identity derived from the div-curl lemma and a modification of the Lax entropy pairs are given and applied to the solution. C.D.

**A86-17776#**

### APPLICATION OF NLR'S CALCULATION METHODS TO TRANSONIC FLOW ABOUT OSCILLATING WINGS

M. H. L. HOUNJET, J. T. VAN DER KOLK, and J. J. MEIJER (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1034-1042. Research supported by the Royal Netherlands Air Force. Previously cited in issue 22, p. 3179, Accession no. A84-46113. refs

**A86-17826#**

### SUPERSONIC VISCOUS-INVISCID INTERACTION OF A SWEPT COMPRESSION RAMP WITH A TURBULENT BOUNDARY LAYER

G. R. INGER (Iowa State University of Science and Technology, Ames) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 60 p. refs
(Contract AF-AFOSR-83-0198)
(AIAA PAPER 85-1669)

This paper analyzes the supersonic interaction of a swept infinite compression ramp with an adiabatic turbulent boundary layer by means of a nonasymptotic triple deck approach combined with a nonisotropic eddy viscosity model attributable to Rotta. Fundamentally-based analytical descriptions of the 3-D disturbance flow field are obtained for a wide range of Mach number, Reynolds number, boundary layer shape factor and sweep angles. In particular, the following aspects of the problem are emphasized: (1) the generation of laiarge secondary flow vorticity by the cross flow inside the boundary alyer; (2) fundamental prediction of the dependence of the upstream influence on sweep angle; (3) assessment of the validity of the so-called independence principle, including a determination of the effect of deviations from this principle due to combined compressibility and turbulence effects including the cross-flow component of the interactive turbulence, and (4) examination of the shear stress disturbance region close to the wall to obtain basic predictions for the 3-D skin friction line geometry and flow behavior at the onset of separation. Author

**A86-17845#**

### EXPERIMENTAL INVESTIGATION OF THREE DIMENSIONAL SEPARATION ON AN ELLIPSOID-CYLINDER BODY AT INCIDENCE

R. L. SCHMITT and B. P. G. CHANETZ (ONERA, Chatillon-sous-Bagneux, France) AIAA, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p.
(AIAA PAPER 85-1686)

An ellipsoid-cylinder model is used for the experimental study of the incompressible turbulent three-dimensional separation which is associated with a vortex formation. The model consists of an oblate half-ellipsoid with a cylindrical extension terminated by a flat base inclined at 45 deg with respect ot the model axis, to stabilize the separation on the rear part of the model. The wind tunnel tests are performed for free stream velocities Vo up to 70 m/s and model angles of attack alpha from 0 to 40 deg. Surface flow visualizations and wall pressure measurements permit to select a particularly interesting configuration corresponding to Vo = 50 m/s and alpha = 30 deg, for which the three-dimensional separation occurs on the cylindrical part of the model. The separated region, and in particular the vortex emerging from the boundary layer, is first explored by using a five hole pressure probe. The three-directional laser Doppler velocimetry is used as a second measurement technique to determine the mean velocity field and the components of the Reynolds stress tensor. The influence of the sample size on the uncertainty affecting the statistical values is examined. Regarding the velocity field, the two measurement techniques give results in good agreement. Author

**A86-17847#**

### COMPUTATION OF FLOWFIELDS IN HIGH SOLIDITY AND HIGH TURNING ANGLE CASCADES USING EULER EQUATIONS

B. N. SRIVASTAVA (Avco Everett Research Laboratory, Inc., Everett, MA) and R. BOZZOLA (Avco Corp., Lycoming Stratford Div., CT) AIAA, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 17 p. Research supported by the Avco Corp. refs
(AIAA PAPER 85-1705)

Flow problems arising in connection with the design of gas turbine engine components have led to the development of computational methods as design analysis tools. The present study is concerned with the development of two Euler codes for computing flowfields in cascades. One code is based on C-grid topology, while the other is based on H-grid topology. The validity of the computational formulation is established by developing numerical solutions for subsonic and transonic flows in several high turning angle and high solidity turbine cascades. The considered cascades are representative of advanced turbine technology. Attention is given to the numerical approach used for boundary treatments and the artificial damping procedure, the grid generation procedure, stator cascade computations, and rotor cascade calculations. G.R.

**A86-17849#**

### NUMERICAL COMPUTATION OF UNSTEADY TRANSONIC FLOW ABOUT WINGS WITH FLAPS

W. A. SOTOMAYOR (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and C. J. BORLAND (Boeing Military Airplane Co., Seattle, WA) AIAA, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 14 p. Research supported by the Boeing Military Airplane Co. and USAF. refs
(AIAA PAPER 85-1712)

Numerical computations for steady and unsteady transonic flow about highly tapered wings with trailing edge flaps are presented. Control surface boundary conditions for an algorithm known as XTRAN3S are described in this paper. Numerical results and comparisons with experiment are shown for M = .90, .925, .95, and .99 for steady and unsteady flow about a model tested by NLR of the Netherlands. In addition,for M = .95, preliminary work indicates that numerical solutions are exhibiting non-uniqueness. Author

**A86-17886**

### ON THE NUMERICAL SOLUTION OF NONLINEAR PROBLEMS IN FLUID DYNAMICS BY LEAST SQUARES AND FINITE ELEMENT METHODS. II APPLICATIONS TO TRANSONIC FLOW SIMULATIONS

M. O. BRISTEAU, O. PIRONNEAU (Institut National de Recherche en Informatique et en Automatique, Rocquencourt, France), R. GLOWINSKI (Paris VI, Universite, France), J. PERIAUX, P. PERRIER (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) et al. (DFG, Universitaet Stuttgart, and U.S. Army, Fenomech '84 International Conference on Finite Elements in Nonlinear Mechanics, 3rd, Stuttgart, West Germany, Sept. 10-14, 1984) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 51, Sept. 1985, p. 363-394. refs

Methods for the numerical solution of the full potential equation modelling transonic flows are presented. It is shown how the general methods discussed in Bristeau et al., (1979) apply to the solution of a class of rather complicated nonlinear problems of industrial interest, namely the numerical simulation of potential transonic flows for compressible inviscid fluids, in two and three dimensions. The governing equations and the various conditions that physical solutions have to verify, such as entropy and Kutta-Joukowsky conditions, are reviewed. The possible existence of multiple physical solutions is considered. The least squares formulation for the continuous problem discussed by Bristeau et al. (1979) is recalled, and the finite element approximation of the formulations of the continuous problem is described. The finite element implementation of the entropy conditions by upwinding of the density in the flow direction is discussed. Various numerical experiments illustrating the possibility of the discussed methods are given. C.D.

**A86-17889**

### SOME RECENT DEVELOPMENTS IN NUMERICAL METHODS FOR TRANSONIC FLOWS

A. JAMESON (Princeton University, NJ) and W. SCHMIDT (Dornier GmbH, Friedrichshafen, West Germany) (DFG, Universitaet Stuttgart, and U.S. Army, Fenomech '84 International Conference on Finite Elements in Nonlinear Mechanics, 3rd, Stuttgart, West Germany, Sept. 10-14, 1984) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 51, Sept. 1985, p. 467-493. refs

A satisfactory numerical method for calculating steady solutions of the Euler equations for inviscid compressible gas flows and extensions the treatment of the Navier-Stokes equations and time-dependent flows are discussed. Modifications of the Euler equations for faster convergence to a steady state are reviewed, and a spatial discretization scheme which is derived from the integral form of the conservation laws is discussed. A relatively simple form of adaptive dissipation is considered which leads to reasonable satisfactory modelling for shock waves in steady flows. Modifications to improve shock resolution are examined. A class of hybrid multistage time-stepping schemes is presented, and the residual-averaging and multiple-grid schemes are reviewed. The treatment of boundary conditions is summarized, and results showing the influence of variations in parameters and mesh effects are given. C.D.

**A86-18047#**

### DRAG REDUCTION OF PERFORATED AXISYMMETRIC BODIES IN SUPERSONIC FLOW

E. SERBANESCU and G. SAVU (Institutul National Pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, Nov.-Dec. 1985, p. 663-665. refs

A numerical treatment for self-adaptive boundary layer laminarization is developed for supersonic bodies-of-revolution with perforated surfaces. The aerodynamic mechanism by which upstream (high pressure) boundary flow is induced through the perforated skin and exhausted, again through the skin, at the trailing (low pressure) surfaces of the body, is governed by the Darcy law. Both spindle-shaped and cone-cylinder axisymmetric bodies are treated. O.C.

**A86-18152**

### THE EFFECT OF THE CURVATURE OF THE EXTERNAL CONTOURS OF TURBINE BLADE PROFILES ON THEIR AERODYNAMIC CHARACTERISTICS [VLIIANIE KRIVIZNY NARUZHNYKH OBVODOV PROFILEI LOPATOK TURBIN NA IKH AERODINAMICHESKIE KHARAKTERISTIKI]

A. V. DEREVIANKO and S. Z. KOPELEV Akademiia Nauk SSSR, Izvestiia, Energetika i Transport (ISSN 0002-3310), Sept.-Oct. 1985, p. 166-170. In Russian. refs

The effect of curvature distribution over the contour of a blade profile on its aerodynamic characteristics is analyzed with particular reference to profile cascades whose contours are described by Bernoulli lemniscates. A criterion for optimum curvature distribution and an algorithm implementing this criterion are proposed. A method is presented for designing blade rings with optimum curvature distribution which meet the engineering, strength, and structural requirements for turbomachine blades. V.L.

**A86-18450#**

### INTAKE AERODYNAMICS

J. SEDDON (Bristol, University, England) and E. L. GOLDSMITH (Royal Aeronautical Establishment, Bedford, England) New York/London, American Institute of Aeronautics and Astronautics/Collins Professional and Technical Books, 1985, 471 p. refs

A comprehensive physical treatment is presented for the fluid dynamics of both subsonic and supersonic aircraft engine air intakes, first treating internal intake duct flow to the engine, from initial freestream conditions, through successively faster speed regimes, and then proceeding to intake external drag. Attention is given to pressure recovery in subsonic intakes, transonic effects of preentry flow, lip separation and transonic throat flow, external and internal supersonic compression, losses in supersonic intakes, and boundary layer bleeds and diverters. Also discussed are the shock oscillation of supersonic intakes, distortion and swirl phenomena, intakes at incidence, and novel intake designs and related devices. O.C.

**A86-18528*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### DELTA WINGS WITH SHOCK-FREE CROSS FLOW

S. S. SRITHARAN (NASA, Langley Research Center, Institute for Computer Applications in Science and Engineering, Hampton, VA) Quarterly of Applied Mathematics (ISSN 0033-569X), vol. 43, Oct. 1985, p. 275-286. Previously announced in STAR as N84-19282. refs

(Contract NAS1-17070)

In order to have a high level of maneuverability, supersonic delta wings should have a cross flow that is free of embedded shock waves. The conical cross flow sonic surface differs from that of plane transonic flow in many aspects. Well-known properties such as the monotone law are not true for conical cross flow sonic surfaces. By using a local analysis of the cross flow sonic line, relevant conditions for smooth cross flow are obtained. A technique to artificially construct a smooth sonic surface and an efficient numerical method to calculate the flow field are used to obtain cones with smooth cross flow. A.R.H.

**A86-18529**

### UNSTEADY TRANSONIC FLOWS IN AN AXIAL FLOW COMPRESSOR

A. R. MANWELL Quarterly of Applied Mathematics (ISSN 0033-569X), vol. 43, Oct. 1985, p. 369-383. refs

Some transonic flow problems of the supersonic axial flow compressor which arise in connection with flutter analysis for fan blading are addressed. Unsteady plane transonic flows through a cascade of flat plates are treated as boundary value problems for the reduced wave equations of supersonic and subsonic flow, with particular reference to the rotor in a finite duct and a nonuniform incident stream. The supersonic entry problem is solved for sigma - 0 , pi by Fredholm theory. For small frequencies, it is shown that the solution depend on the duct length, in some cases very significantly. A uniqueness proof is given which requires strong conditions on the incident stream; in an appendix, a counterexample for a differential equation of the same general class is given. C.D.

**A86-18534**

### THE VORTEX PATTERNS OF DYNAMIC SEPARATION - A PARAMETRIC AND COMPARATIVE STUDY

P. FREYMUTH (Colorado, University, Boulder) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 22, no. 3, 1985, p. 161-208. refs

(Contract AF-AFOSR-81-0037)

The present flow visualization study of vortical pattern development during dynamic separation in accelerating flow around airfoils, for Reynolds numbers of 16, 124, 1000, 5200, 18,500, and 52,000, proceeds to develop a descriptive nomenclature for the effects thus identified. This 'dictionary' is then applied to the comparative study of vortex patterns for several dynamically separating flow configurations. The flow visualization technique used in the photographic portion of the present study is that of TiCl4 smoke generation, and the airfoil is of NACA 0015 profile. O.C.

**A86-18535**

### SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION AND ITS CONTROL

J. M. DELERY (ONERA, Chatillon-sous-Bagneux, France) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 22, no. 4, 1985, p. 209-280. refs

The interaction between a shock wave and a boundary layer often leads to extremely detrimental effects, especially if the shock is strong enough to separate the boundary layer. When this happens, there occurs a rapid growth of the dissipative region along with a dramatic intensifying of turbulent fluctuations with the frequency occurrence of buffeting. In the present review some fundamental properties of the interaction are first considered for a two-dimensional, adiabatic flow developing on a flat surface. The following features are first examined: upstream interaction length, incipient shock-induced separation and evolution of the boundary layer properties during the interaction process. Supersonic and transonic flows are both considered. In a second part, the means envisaged to control shock-boundary layer interactions are presented, with emphasis on the physics of phenomena involved in this process. Control methods can be classified into two categories: those acting on the boundary layer properties before it enters the shock region (e.g. wall cooling, wall mass transfer, upstream blowing) and those having a local action in the shock foot region itself (e.g. suction or injection, boundary layer removal, passive control). The most appropriate technique depends on the specific application under consideration. Finally, some calculation methods are briefly presented, most of them being restricted to laminar interactions. Author

**A86-18577*** Iowa State Univ. of Science and Technology, Ames.

### LARGE-SCALE SEPARATION AND HYSTERESIS IN CASCADES

A. P. ROTHMAYER (Iowa State University of Science and Technology, Ames) and F. T. SMITH (University College, London, England) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 402, no. 1822, Nov. 8, 1985, p. 83-108. refs

(Contract N00014-76-C-0634; NGT-36-004-800)

An approach using a two-dimensional thin aerofoil, allied with the theory of viscous bluff-body separation, is used to study the initial cross-over from massive separation to an attached flow in a single-row unstaggered cascade. Analytic solutions are developed for the limit of small cascade-spacing. From the analytic solutions several interesting features of the cascade are examined, including multiple-solution branches and multiple regions of hysteresis. In addition, numerical results are presented for several selected aerofoils. Some of the aerofoils are found to contain markedly enlarged regions of hysteresis for certain critical cascade spacings. Author

**A86-18686#**

### COMPUTATION OF UNSTEADY TRANSONIC FLOWS WITH AN IMPLICIT NUMERICAL METHOD FOR SOLVING THE EULER EQUATIONS

J. SIDES (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1985, p. 17-39. refs

The Lerat et al. (1982) implicit method for accurate and efficient solution of the Euler equations is presently applied to the computation of transonic flows, with a view to the prediction of aeroelastic phenomena over airfoils. Numerical applications are performed which were chosen among test cases defined by AGARD's 'Standard Aeroelastic Configurations' working group, relating to the NACA 64A010 airfoil in pitch oscillations and to the NLR 7301 supercritical airfoil with an oscillating flap. The results obtained are compared with experimental data and with the transonic small disturbance approach. O.C.

**A86-18902**

**A COMPRESSIBLE LAMINAR BOUNDARY LAYER ON A PLANE TRIANGULAR PLATE WITH AN ATTACHED SHOCK WAVE [SZHIMAEMYI LAMINARNYI POGRANICHNYI SLOI NA PLOSKOI TREUGOL'NOI PLASTINE S PRISOEDINENNOI UDARNOI VOLNOI]**

V. N. VETLUTSKII and T. V. POPLAVSKAIA PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1985, p. 23-29. In Russian. refs

A laminar boundary layer on the windward side of a plane triangular plate is analyzed quantitatively. In particular, expressions are obtained which relate local coefficients of friction resistance and Stanton numbers, as well as integral coefficients of friction resistance and heat fluxes, to the principal parameters of the problem, namely, the Mach number, angle of attack, angle of sweep, and relative wall enthalpy. V.L.

**A86-18903**

**FLOW PAST CARET WINGS WITH FLAPS [OBTEKANIE CARET-KRYL'EV S ZAKRYLKAMI]**

O. N. IVANOV and A. I. SHVETS PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1985, p. 41-46. In Russian. refs

Results of an experimental study of subsonic and supersonic flow past delta wings with an inverted-V cross section equipped with flaps and having a sweep angle of 71 deg are presented for flare angles of 180, 161, and 120 deg and flap angles of 0, 21, and 40 deg. Determinations are made of pressure distribution along the central chord of the wing and on the flaps. Also, the structure of shock waves produced during supersonic flow past a caret wing with flaps, a cone, and a wedge is analyzed. V.L.

**A86-18904**

**DETERMINATION OF THE INTENSITY OF A FREE VORTEX SHEET IN THE CONTEXT OF AIRFOIL THEORY [OPREDELENIE INTENSIVNOSTI SVOBODNOI VIKHREVOI PELENY V RAMKAKH TEORII NESUSHCHEI POVERKHNOSTI]**

N. F. VOROBEV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1985, p. 46-50. In Russian. refs

For a lifting surface in subsonic incompressible potential flow, the conditions determining the intensity of a free vortex sheet produced by the leading (side) edge are determined on the basis of the vortex line conservation law. In the case of the discrete vortex scheme of a slender wing of finite span considered here, the dependence of the vortex sheet intensity on the angle of sweep is obtained in explicit form. For slender rectangular and triangular plates, the results of calculations of integral aerodynamic characteristic are compared with experimental data. V.L.

**A86-19005**

**BEHAVIOUR OF A RECTANGULAR WING IN A SUPERSONIC FLOW - DYNAMIC PRESSURE AND NORMAL FORCE ANALYSIS IN THE RANGE 1.3-4.0 MACH**

J. E. ETEROVIC, O. M. BARTUREN, and H. O. QUARANTA (Comision Nacional de Investigaciones Espaciales, Centro Espacial San Miguel, Argentina) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 53, Oct. 1985, p. 91-94.

The calculation of the total normal forces and the dynamic pressure on a rectangular wing at different rocket velocities is presented. Two programs for computer-aided design of rocket wings were developed. Variations of velocity and air temperature modify the expected performance curves. Author

**A86-19148**

**CRITICAL PERMEABILITY PARAMETER IN SUPERSONIC GRADIENT FLOW**

V. M. EPIFANOV, A. I. LEONTEV, A. M. PAVLIUCHENKO, and A. V. PASHUTOV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) (Teplofizika Vysokikh Temperatur, vol. 23, Mar.-Apr. 1985, p. 336-339) High Temperature (ISSN 0018-151X), vol. 23, no. 2, Sept. 1985, p. 279-282. Translation. refs

Results are presented from an experimental study of characteristics of a supersonic turbulent boundary layer with injection through a porous wall under conditions of interaction with an incident shock and flow in a compression section and ahead of a step. Conditions of flow separation are established and the dependence of the critical injection parameter on the form parameter of the pressure gradient is determined. Author

**N86-14217#** National Aerospace Lab., Tokyo (Japan).

**GRID GENERATION FOR SINGLE AIRFOIL USING CONFORMAL MAPPING**

Feb. 1985 6 p refs

(NAL-TR-8511; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

A method to generate girds for numerical computation for an arbitrary single airfoil section using conformal mapping is presented in this paper. The function which maps conformally the region exterior to the airfoil section onto the exterior of the unit circle is determined by the method developed by Moriya and Imai. O,h-and C-type grids are generated with the mapping function. Author

**N86-14218*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**THEORETICAL AND EXPERIMENTAL FLOW FIELDS FOR A SUPERSONIC CRUISE FIGHTER FOREBODY**

S. F. YAROS Nov. 1985 43 p refs

(NASA-TM-86450; L-15914; NAS 1.15:86450) Avail: NTIS HC A03/MF A01 CSCL 01A

The capability of two numerical methods to predict the flow field about a representative supersonic cruise aircraft was examined. The two codes were a small-disturbance transonic program of Boppe and a conservative form full-potential transonic program of Shankar and Szema. For the former code, comparisons were made with wind-tunnel data at Mach numbers of 0.6, 0.9, and 1.2 and angles of attack of 0 deg, 5 deg, and 10 deg (7.5 deg instead of 10 deg at a Mach number of 1.2). Predictions from the two codes were compared at a Mach number of 1.2 and an angle of attack of 7.5 deg. The comparison criteria were contours of local angle of attack, local angle of sideslip, and local Mach number. The comparisons indicated that both codes may be considered useful for design applications, depending on the degree of accuracy required by the user's solution. Both solutions show an inaccuracy in their predictions, particularly as Mach number and/or angle of attack increases, because of their lack of viscous effects and any mechanisms to predict vortex development. Author

**N86-14220*#** DEI-Tech, Inc., Newport News, Va.

**AN AIRFOIL FLUTTER MODEL SUSPENSION SYSTEM TO ACCOMMODATE LARGE STATIC TRANSONIC AIRLOADS Final Report**

W. H. REED, III Oct. 1985 39 p refs

(Contract NAS1-17686)

(NASA-CR-177998; NAS 1.26:177998; D-8402-3) Avail: NTIS HC A03/MF A01 CSCL 01A

A pitch/plunge flutter model suspension system and associated two-dimensional MBB-A3 airfoil models is described. The system is designed for installation in the Langley 6-by-19-inch and 6-by-18-inch transonic blowdown wind tunnels to enable systematic study of the transonic flutter characteristics and static pressure distributions of supercritical airfoils at transonic Mach numbers. A compound spring suspension concept is introduced which simultaneously meets requirements for low plunge-mode stiffness, lightweight suspended model, and large steady lift due to angle of attack without the need for excessive static deflections of the plunge spring. The system features variable pitch and plunge frequencies, changeable airfoil rotation axes, and a self aligning control system to maintain a constant mean position of the model with changing airload. Author

**N86-14221*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A FOURTH-ORDER SCHEME FOR THE UNSTEADY COMPRESSIBLE NAVIER-STOKES EQUATIONS Final Report**

A. BAYLISS, P. PARIKH, L. MAESTRELLO, and E. TURKEL Oct. 1985 26 p refs Submitted for publication
(Contract NAS1-17070; NAS1-17130)
(NASA-CR-177994; ICASE-85-44; NAS 1.26:177994) Avail: NTIS HC A03/MF A01 CSCL 01A

A computational scheme is described which is second-order accurate in time and fourth-order accurate in space (2-4). This method is applied to study the stability of compressible boundary layers. The laminar compressible Navier-Stokes equations are solved with a time harmonic inflow superimposed on the steady state solution. This results in spatially unstable modes. It is shown that the second-order methods are inefficient for calculating the growth rates and phases of the unstable modes. In contrast the fourth-order method yields accurate results on relatively course meshes. Author

**N86-14222*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SEMIEMPIRICAL METHOD FOR PREDICTING VORTEX-INDUCED ROLLING MOMENTS**

D. O. ALLISON and P. J. BOBBITT Nov. 1985 19 p refs
(NASA-TM-87579; L-15986; NAS 1.15:87579) Avail: NTIS HC A02/MF A01 CSCL 01A

A method is described for the prediction of rolling moments on a wing penetrating a vortex velocity field generated by a large aircraft. Rolling moments are determined from lifting pressure coefficients computed with an inviscid-flow linear panel method. Two empirical corrections are included to account for the lifting efficiency of an airfoil section and the local stall on the wing. Predicted rolling moments are compared with those from two windtunnel experiments. Results indicate that experimental rolling moments, for which the Reynolds number of the following wing is low, should be interpreted with caution. Author

**N86-14223*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**VELOCITY AND TEMPERATURE DECAY CHARACTERISTICS OF INVERTED-PROFILE JETS**

U. VONGLAHN, J. GODDYKOONTZ, and C. WASSERBAUER 1985 32 p refs To be presented at the 24th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1986; sponsored by American Inst. of Aeronautics and Astronautics
(NASA-TM-87159; E-2681; NAS 1.15:87159; AIAA-86-0312)
Avail: NTIS HC A03/MF A01 CSCL 01A

In order to design efficient, lightweight flap systems for future engine under-the-wing STOL aircraft, the velocity and temperature decay rate of the jet plume must be increased relative to that for single-stream nozzles in order to provide local flap loads and structural temperatures within acceptable limits. The jet plume decay rate of dual flow engines can be increased by resorting to inverted-profile velocity and temperature nozzle concepts. The peak axial decay characteristics of model-scale, two-stream inverted-profile nozzle flows are empirically correlated. Also discussed are the radial and spreading characteristics of inverted-profile nozzle flows. Author

**N86-14224*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**A MODEL FOR CLOSING THE INVISCID FORM OF THE AVERAGE-PASSAGE EQUATION SYSTEM**

J. J. ADAMCZYK, R. A. MULAC (Sverdrup Technology, Inc., Middleburg Heights, Ohio), and M. L. CELESTINA (Sverdrup Technology, Inc., Middleburg Heights, Ohio) 1985 15 p refs To be presented at the 31st International Gas Turbine Conference, Dusseldorf, West Germany, 8-12 June 1986; sponsored by the American Society of Mechanical Engineers
(NASA-TM-87199; E-2854; NAS 1.15:87199) Avail: NTIS HC A02/MF A01 CSCL 01A

A mathematical model is proposed for closing or mathematically completing the system of equations which describes the time average flow field through the blade passages of multistage turbomachinery. These equations referred to as the average passage equation system govern a conceptual model which has proven useful in turbomachinery aerodynamic design and analysis. The closure model is developed so as to insure a consistency between these equations and the axisymmetric through flow equations. The closure model was incorporated into a computer code for use in simulating the flow field about a high speed counter rotating propeller and a high speed fan stage. Results from these simulations are presented. Author

**N86-14225#** Deutsche Gesellscaft fuer Luft und Raumfahrt, Bonn (West Germany).

**THE STATE OF DEVELOPMENT RESEARCH IN NUMERICAL AERODYNAMICS IN WEST GERMANY [NUMERISCHE AERODYNAMIK - STAND DER ENTWICKLUNG IN DEUTSCHLAND]**

1984 175 p refs Partly in GERMAN and ENGLISH Symp. held at Neubiberg, West Germany, 2-3 Jul. 1984
(DGLR-84-01; ISBN-3-922010-25-3) Avail: NTIS HC A08/MF A01

Among the topics discussed at the Symposium in Neubiberg 2 to 3 July 1984 on the status of Research in Numnerical Aerodynamics in West Germany were the following: Solutions of the Navier-Stokes equations; the Euler equations; and of the full potential equations.

**N86-14226#** Deutsche Gesellscaft fuer Luft und Raumfahrt, Bonn (West Germany).

**SUMMARY REPORT ON THE WORKING GROUP FOR CONFERENCE 1: SOLUTIONS OF THE NAVIER-STOKES EQUATIONS [ZUSAMMENFASSENDER BERICHT DER ARBEITSGRUPPE ZUR SITZUNG 1. LOESUNGEN DER NAVIER-STOKES'SCHEN GLEICHUNGEN]**

D. HAENEL, W. HAASE, W. KORDULLA, and D. SCHWAMBORN *In its* The State of Development Research in Numerical Aerodynamics in West Germany p 5-7 1984 In GERMAN
Avail: NTIS HC A08/MF A01

Applications of numerical procedures for solution of the Euler equations to three dimension studies, to the production of body-adapted grids, to the construction of block-structured differential grids, to the formulation of the boundary transition conditions, and to the determination of aerodynamic factors are discussed. Application of a finite volume method to the formulation and discretization of the conservation equations; and application of the Navier-Stokes solutions in two dimensions to the study of numerical aerodynamics using supercomputers of the CRAY 1S type are considered. Investigations of separated flow and vorticity are reviewed. Further investigation of the Navier-Stokes equations are recommended to develop physical model representations on transition and turbulence and to study their applicability to 3-D configurations. Author (ESA)

**N86-14227#** Deutsche Gesellscaft fuer Luft und Raumfahrt, Bonn (West Germany).

**SUMMARY REPORT ON THE WORKING GROUP ON CONFERENCE 2: SOLUTIONS OF THE EULER EQUATIONS [ZUSAMMENFASSENDER BERICHT DER ARBEITSGRUPPE ZUR SITZUNG 2. LOESUNGEN DER EULER-GLEICHUNGEN]**

A. DAS, A. EBERLE, J. GRASHOF, and W. SCHMIDT *In its* The State of Development Research in Numerical Aerodynamics in West Germany p 8-10 1984 In GERMAN

Avail: NTIS HC A08/MF A01

Comparison of the Euler equations and the potential theory for supersonic flows; solutions in full potential theory in approximation steps for total pressure loss study and for trailing edge study; application of dynamic adaptative grids in the solution of 1-D hyperbolic equations; and solution of the time-dependent Euler equations are discussed. Author (ESA)

**N86-14229#** Technische Hochschule, Darmstadt (West Germany). Fachbereich Mathematik.

**AN IMPLICIT FINITE-DIFFERENCE PROCEDURE FOR THE NUMERICAL SOLUTION OF UNSTEADY SUPERSONIC FLOW OVER A BLUNT BODY**

M. S. ABOUEL-SEOUD *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 14-19 1984 refs

Avail: NTIS HC A08/MF A01

An axisymmetric supersonic viscous flow over a blunt body is simulated with solution of the unsteady Navier-Stokes equations with thin layer approximation. The numerical algorithm used to solve the conservation law form for the thin layer Navier-Stokes equations for time-dependent compressible flow is based on an implicit iterative scheme. The convergence of the numerical algorithm and the stability of the corresponding nonlinear system of equations are ensured by selected discretization parameters and dissipative coefficients. Author (ESA)

**N86-14231#** Technische Hochschule, Aachen (West Germany). Inst. fuer Aerodynamik.

**SOLUTIONS OF THE NAVIER-STOKES EQUATIONS FOR VORTICAL FLOW [LOESUNGEN DER NAVIER-STOKES GLEICHUNGEN FUER WIRBELBEHAFTETE STROEMUNGEN]**

D. HAENEL *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 27-28 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Investigations of flows with vortices are reviewed. Incompressible flow (calculation of the leading edge vortex on delta wings) and compressible flow (solutions of the Navier-Stokes equations using implicit factorization and using the multigrid method) are discussed. Author (ESA)

**N86-14232#** Technische Hochschule, Aachen (West Germany).

**NUMERICAL CALCULATION OF LEADING-EDGE VORTICES ON A FLAT DELTA WING Thesis**

P. M. HARTWICH *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 29-43 1984 In GERMAN

Avail: NTIS HC A08/MF A01

Finite difference solutions of the Navier-Stokes and Euler equations were applied to study a 3-D incompressible flow over a flat wing using an artificial compressibility. The results for viscous and inviscid flows were compared. The truncation errors near the leading edge resulting in numerical dissipation and vorticity in Euler solution are studied with a 2-D inviscid flow over a vertical plate. Numerical simulations are made to study the breakdown of an isolated vortex, the flow over a 2-D car model and the viscous flow over a backward facing step. Vortex stability and bubble structure are studied. Author (ESA)

**N86-14233#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Theoretische Stroemungsmechanik.

**SIMULATION OF THREE-DIMENSIONAL VISCOUS TRANSONIC FLOWS [SIMULATION REIBUNGSBEHAFTETER 3-D TRANSSONISCHET STROEMUNGEN]**

W. KORDULLA *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 44-48 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Viscous transonic flows over a semiconical-cylindrical configuration are simulated on a CRAY 1S supercomputer using a modified version of the explicit implicit McCormack method based on the finite volume method and using the level concept for measuring the pressure distribution to study the asymptotic behavior of the flow on body surfaces. Measures of the pressure distributions are discussed for angles of attack ranging from 0 to 19 deg. Flow vorticity and asymptotic wall flow line direction are studied using an improved mesh grid. The calculations allow the determination of the forces resulting from a flow over a body to be performed. The integration method is applied to simulate the flow around a body. Author (ESA)

**N86-14234#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Theoretische Stroemungsmechanik.

**CALCULATION OF AXISYMMETRIC LAMINAR SUPERSONIC FLOWS OVER BLUNT BODIES [BERECHNUNG ACHSENSYMMETRISCHER LAMINARER UEBERSCHALLSTROEMUNGEN UM STUMPFE KOERPER]**

B. MUELLER *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 49-53 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

The implicit Beam and Warming difference procedure is applied to solve the axisymmetric Euler and Navier-Stokes equations in thin layer approximation used to study the effects of viscosity in supersonic flow over blunt bodies at high Reynolds numbers. A numerical program is developed and its economical application regarding time saving and calculation speed is tested by calculating the laminar flows over a semispherical cylindrical configuration and over a spherical blunt cone with adiabatic and isothermal walls at Mach numbers from 12 to 20.3. The theoretical results show good agreement with experiments. The numerical simulation allows the prediction of the separation point. The validity of the thin layer approximation for flows with large separation area is demonstrated by comparing the thin layer equations with the full Navier-Stokes equations for supersonic flow over a blunt body of revolution. Author (ESA)

**N86-14235#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Theoretische Stroemungesmechanik.

**SOLUTIONS OF THE NAVIER-STOKES EQUATIONS WITH THE FINITE VOLUME METHOD [NAVIER-STOKES LOESUNGEN MIT FINITEN VOLUMEN VERFAHREN]**

D. SCHWAMBORN and E. KATZER *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 54-60 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

The effects of friction and separation on flow distribution are calculated with three dimensional boundary methods to develop a modular program system for solution of the Navier-Stokes and Euler equations for profiles, wings, and blunt bodies and for investigation of impact-boundary layer interaction on plate and profile, of the flow over a semicylinder on a plate, of boundary layer - pressure wave interaction, and wake flows. The effects of the grids and the synthetic dissipation on the solution are studied and turbulent model modules are tested to simulate turbulent flows. The solutions are verified with comparative calculations. Tests are performed with Poiseuille flow, Couette flow, and the boundary layer on a plane plate. The development of simple models of the impact-boundary layer interaction is based on the relation between the separation bubble length and Mach and Reynolds numbers and the impact force. Author (ESA)

**N86-14236#** Stuttgart Univ. (West Germany). Inst. fuer Raumfahrtantriebe.

**A NAVIER-STOKES PROCEDURE FOR SIMULATION OF TWO-DIMENSIONAL AND QUASI TWO-DIMENSIONAL GRID FLOWS [EIN NAVIER-STOKES VERFAHREN ZUR SIMULATION ZWEIDIMENSIONALER UND QUASI-ZWEIDIMENSIONALER GITTERSTROEMUNGEN]**

O. SCHAEFER *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 61-71 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

A Navier-Stokes procedure for simulation of a flow through straight blade grids is improved. A quasi 2-D formulation of the equations account for the effects of nonparallel lateral walls. A more accurate spatial discretization around singular points is achieved. Overlapping calculation meshes in periodical areas and a more accurate introduction of the periodicity condition; a total implicit boundary condition for C-meshes as well as specific finite volume operators for singular points are described. Author (ESA)

**N86-14238#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

**PROCEDURE FOR SOLUTION OF THE NAVIER-STOKES EQUATIONS AT DORNIER GMBH [LOESUNGSVERFAHREN FUER DIE NAVIER-STOKES-GLEICHUNGEN BEI DER FIRMA DORNIER]**

W. HAASE *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 74-77 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Simulations using the solutions of the Navier-Stokes equations are studied. Flow over profiles using the solution adaptive grid method; cascade flow using the McCormack scheme; shock-boundary layer interaction using the McCormack scheme and the Runge-Kutta time-stepping scheme; flow over afterbodies using the McCormack scheme; flow over car models using the block-structured grid method; and engine internal flow are considered. Author (ESA)

**N86-14239#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Unternehmensgruppe Hubschrauber und Flugzeuge.

**COMPARISON OF THE EULER AND POTENTIAL SOLUTIONS FOR SUPERSONIC FLOWS OVER DELTA WINGS [VERGLEICH VON EULER- UND POTENTIALLLOESUNGEN FUER UEBERSCHALLSTROEMUNGEN AN DELTAFLUEGELN]**

C. WEILAND *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 78-85 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Supersonic flows over delta wings are studied using the Euler procedure associated with the shock fitting method to determine the head shock wave and using the potential procedure with the shock capturing method to determine the position and force of the head shock wave. The flow distribution can be economically described with the potential procedure and not with the Euler procedure. The entropy rises due to compression shocks along the flow lines and the entropy gradients due to the compression shock curvature can be explained with the Euler equations. The results of the Euler solution for a delta wing were compared with those of the potential solution using photographs. Further investigations are recommended to study the influence of the elimination of entropy variations on the solutions. Author (ESA)

**N86-14240#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Unternehmensgruppe Hubschrauber und Flugzeuge.

**TRAILING EDGE FLOW WITH TRANSONIC PROFILES [ZUR HINTERKANTENSTROEMUNG BEI TRANSSONISCHEN PROFILEN]**

E. H. HIRSCHEL and C. W. LUCCHI *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 86-92 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

The trailing edge in subcritical and supercritical flows is studied regarding pressure, velocity and friction effects to determine the relation between the Kutta angle in inviscid flow and the profile curvature due to compression shock on the suction side of the airfoil profile. The Euler procedure is used to determine the correlation between the numerical results. The vorticity in supercritical flow is studied with solutions of potential theory and cinematically. Results show that profile curvature is due to pressure loss at rest, nonuniqueness of the numerical methods for the trailing edge, and possible relaxation of the potential method. Author (ESA)

**N86-14241#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Theoretical Aerodynamics Div.

**A NEW EULER ALGORITHM BASED ON CHARACTERISTIC FLUX EXTRAPOLATION**

A. EBERLE *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 93-100 1984

Avail: NTIS HC A08/MF A01

An asymmetric weighting procedure based on the eigenvalue decomposition of the Euler equations is developed for flow variables at cell faces to calculate flux extrapolation. Left and right states are defined by linear combinations of the flow quantities of the two adjacent cells on each side of a volume cell face. They are weighted with elements of the split matrix to obtain the averaged flow values and the Euler fluxes. Cell midpoint values are updated with the centered difference operator applied on the fluxes. The scheme is accurate in space and time in the pseudo-unsteady option and is entropy-conditioned. Author (ESA)

**N86-14242#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Abt. Theoretische Aerodynamik.

**PROCEDURE FOR SOLUTION OF THE EULER EQUATIONS AT DORNIER GMBH [LOESUNGSVERFAHREN FUER DIE EULER-GLEICHUNGEN BEI DER FIRMA DORNIER]**

J. GRASHOF *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 101-104 1984 In GERMAN

Avail: NTIS HC A08/MF A01

A solution procedure of the Euler equations is developed for prediction of the flows on aircraft and aircraft components for aerodynamic design. Its applications and versions are listed according to the grid structure. The numerical accuracy of the Euler calculations is demonstrated with 2-D flow numerical examples taking into account the comparison of the Euler solution with the potential solution in subsonic flow, total pressure analysis, the influence of the grids on the results, and convergence acceleration. Numerical examples in 2-D and 3-D flows are presented as well as the results of the numerical simulation of the leading edge vorticity. Author (ESA)

**N86-14243#** Gesellschaft fuer Reaktorsicherheit, Garching (West Germany).

**APPLICATION OF A DYNAMIC GRID ADAPTATION IN THE ASWR PROCEDURE [VERWENDUNG EINER DYNAMISCHEN GITTERANPASSUNG IM ASWR-VERFAHREN]**

U. GRAF, P. ROMSTEDT, and W. WERNER *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 105-111 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

A dynamic grid adaptation method is developed for the ASWR procedure to determine automatically the spatial grid with the solution of hyperbolic or parabolic vector partial difference equations. The grid adaptation algorithm is based on a minimization of the L2-standard of the spatial discretization error. Accurate calculation of the solutions with inhomogeneity or transitions on a coarse grid is performed with a reduced number of grid points using the method. The calculation is based on fixed equidistant Euler grids with reduced calculation time. Author (ESA)

**N86-14245#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).

**CONTRIBUTION TO THE POTENTIAL CALCULATION OF ANISOTROPIC COMPRESSION SHOCKS IN A PLANE CASE [BEITRAG ZUR POTENTIALTHEORETISCHEN BERECHNUNG NICHTISENTROPER VERDICHTUNGSSTOESSE IM EBENEN FALL]**

K. D. KLEVENHUSEN *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 121-126 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Anisotropic compression shocks are produced based on the potential theory with a swelling flow from the impact location and a determined swelling force for a perpendicular impact, to study the lift on a profile and get a more accurate physical description of a real flow. Impact location shows good agreement with the Euler solutions. The entropy rise due to the impact can be calculated from conservation laws. Author (ESA)

**N86-14246#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Unternehmensgruppe Hubschrauber und Flugzeuge.

**A PROCEDURE FOR SOLUTION OF FULL POTENTIAL EQUATIONS WITH CORRECTION OF THE TRAILING EDGE CONDITION [EIN VERFAHREN ZUR LOESUNG DER VOLLSTAENDIGEN POTENTIALGLEICHUNG MIT KORREKTUR DER HINTERKANTENBEDINGUNG]**

C. W. LUCCHI *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 127-131 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

A procedure to reduce the differences between the calculated static pressure distributions on profiles and the exact solutions of the Euler equations in the use of conservative potential methods for 2-D transonic flows over profiles is developed. The procedure contains the correction of the static pressure distribution points on and behind the impact on a profile and a form of the Kutta-Jouskowski condition with the Neumann boundary conditions on the profile trailing edge slot. Accuracy is demonstrated with a conservative subdomain finite element method for full potential equations. The results with profiles with or without lift are presented. Author (ESA)

**N86-14247#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

**SHOCK DESIGN FOR REFINED RECALCULATIONS [STOSSENTWURF ALS GRUNDLAGE VERFEINERTER NACHRECHNUNGEN]**

H. SOBIECZKY *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 132-133 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

The fictive gas method for design of shock free transonic configurations based on the formulation of the boundary problems of transonic differential equations is extended to compression shock using the boundary lines for shock formation to explain a supersonic collision flow over a 2-D profile. The method enables the resulting form to coincide with a given form with a supposed accuracy. A recalculation procedure is applied to study the accuracy of the Euler equations with entropy corrections. Author (ESA)

**N86-14248#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.

**REVIEW OF RESEARCH IN NUMERICAL AERODYNAMICS AT THE DFVLR IN BRUNSWICK [UEBERLICK UEBER DIE NUMERISCHE AERODYNAMIK IN DER DFVLR, BRAUNSCHWEIG]**

N. KROLL and A. DAS *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 134-168 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Numerical methods used for fluid mechanics and acoustics investigations are reviewed. Mesh generation with algebraic equations and partial differential equations; solution of the Euler equations for calculation of the flows over profiles; solution of the potential equations for calculation of the flow over profiles and airfoils; and solution of the 2-D incompressible Navier-Stokes equations in body-adapted coordinates are summarized. Author (ESA)

**N86-14249#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

**PROCEDURE FOR SOLUTION OF THE FULL POTENTIAL EQUATION AT DORNIER GMBH [LOESUNGSVERFAHREN FUER DIE VOLLSTAENDIGE POTENTIALGLEICHUNG BEI DER FIRMA DORNIER]**

S. LEICHER *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 169-171 1984 In GERMAN

Avail: NTIS HC A08/MF A01

Numerical procedures for economical solution of the full potential equation for 2-D profiles (systems and optimization) and for 3-D wing and body-wing configurations are reviewed. Further investigations of their coupling with boundary layer methods are recommended. Author (ESA)

**N86-14250*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FLEXWAL: A COMPUTER PROGRAM FOR PREDICTING THE WALL MODIFICATIONS FOR TWO-DIMENSIONAL, SOLID, ADAPTIVE-WALL TUNNELS**

J. L. EVERHART Nov. 1983 53 p
(NASA-TM-84648; NAS 1.15:84648) Avail: NTIS HC A04/MF A01 CSCL 01A

A program called FLEXWAL for calculating wall modifications for solid, adaptive-wall wind tunnels is presented. The method used is the iterative technique of NASA TP-2081 and is applicable to subsonic and transonic test conditions. The program usage, program listing, and a sample case are given. Author

**N86-14251#** Naval Surface Weapons Center, Silver Spring, Md.

**ALTERNATE ALTITUDE TESTING OF SOLID CLOTH PARACHUTE SYSTEMS Final Report**

W. P. LUDTKE 10 Oct. 1985 85 p
(AD-A157068; NSWC/TR-85-24) Avail: NTIS HC A05/MF A01 CSCL 01C

The flight testing of solid cloth parachutes sometimes calls for unique test conditions such as very high altitudes for extremely low dynamic pressures, or heavy payloads, such as cargo tested at low attitudes. Each of these conditions may require exceptional test equipment and/or facilities such as balloon-borne and rocket-assisted high-altitude vehicles or large cargo aircraft for low altitude heavy payloads. These requirements can add significantly to the overall test program cost and complexity. In order to reduce development test costs and complexity, a theoretical study was conducted to determine the possibility of altering the test conditions in a manner which would permit the use of lower cost test assets and still obtain same parachute opening shock forces and stress distributions. The results show that if the system mass and test velocity are varied, as shown in the accompanying method for a constant Ballistic Mass Ratio (BMR) scale parameter, the opening shock force and stress distributions are constant for all altitudes. A technique is described which theoretically permits parachute systems to be tested under more convenient conditions of altitude, velocity, and system mass resulting in the same conditions of opening shock force and parachute stress distribution. GRA

**N86-14256#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Theoretische Stroemungsmechanik.

**CALCULATION OF SEPARATED LAMINAR SUPERSONIC FLOWS OVER BLUNT BODIES OF REVOLUTION AT ZERO ANGLE OF ATTACK Ph.D. Thesis - Technische Hochschule, Aachen**

B. MUELLER Apr. 1985 142 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-953) Sponsored by Deutsche Forschungsgemeinschaft
(DFVLR-FB-85-30; D-82; ISSN-0171-1342) Avail: NTIS HC A07/MF A01; DFVLR, Cologne DM 40.50

The applicability of the thin layer approximation method for the description of thin separation bubbles and large separation areas and data acquisition on the structure of separated three dimensional flow distribution is studied using the numerical simulation of separated laminar supersonic flows over blunt bodies of revolution. The influence of numerical damping on the consistency, stability, convergence and accuracy of the finite difference scheme of Beam and Warming is studied. The topologic stucture of the separation area depends on the Reynolds number. The thin layer approximation allows an accurate description of flows with small or large separation areas at high Reynolds numbers. Author (ESA)

**N86-14257#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensbereich Transporter.

**INTEGRATED WING ENGINE SYSTEM (IFAS), PHASE 2 Final Report, Jun. 1984**

J. SZODRUCH Bonn Bundesministerium fuer Forschung und Technologie Jun. 1985 111 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-85-008; MBB-TE-2-1370; ISSN-0170-1339) Avail: NTIS HC A06/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 23.50

Computational aerodynamic design methods were developed to study the interference transonic flow on engine-wing and body-wing configurations using the hybrid method and flow simulation in wind tunnels. Transonic wing technology was improved regarding fineness ratio, lift and zero moment, stability and buffeting limit on airfoils with economical production methods. Design criteria for transonic wings strong interference were determined in studying the wing-body transition area with existing and newly designed shapes, and the engine-wing interference area with half and complete models. Measurements in subsonic and transonic flows were made using a turbo-powered simulator. High lift systems on transonic wings were studied to improve flap efficiency based on the Swept Constant Chord Halfmodel results, and to design high lift principles for a transonic wing as used on the A-320 aircraft. Author (ESA)

**N86-14422** Yamaguchi Univ., Ube (Japan).

**THE PROPERTIES OF A ROW OF TRAILING VORTICES GENERATED IN THE UNIFORM FLOW. THE PATH OF TRAILING VORTEX**

H. OSAKA, T. YAMAGUCHI, and Y. KAGEYAMA *In its* Memoirs of the Faculty of Engineering, Yamaguchi University, Vol. 36, No. 1 p 25-29 Oct. 1985 refs In JAPANESE; ENGLISH summary
(REPT-1) Avail: NTIS HC A09

Measurements of trailing vortices shedding from a row of wing placed in the uniform flow were made to investigate the properties of those. The wing used has a span of 30 mm and a chord of 20 mm and has a rectangular planform. Velocity profiles were measured at several attack angles and spanwise distance between the wings. In all cases the trailing vortices can be formed behind a row of wing and the spanwise variation of the U-component of mean velocity is produced by those vortices. The path of trailing vortex directs downwards with increasing the attack angle, while its path has a different tendency due to the spanwise distance between the wings. Author

**N86-14423** Yamaguchi Univ., Ube (Japan).

**THE PROPERTIES OF A ROW OF TRAILING VORTICES GENERATED IN THE UNIFORM FLOW. SHAPE OF TRAILING VORTEX AND ITS STREAMWISE VARIATION**

H. OSAKA, T. YAMAGUCHI, and Y. KAGEYAMA *In its* Memoirs of the Faculty of Engineering, Yamaguchi University, Vol. 36, No. 1 p 31-36 Oct. 1985 refs In JAPANESE; ENGLISH summary
(REPT-2) Avail: NTIS HC A09

The measurements of trailing vortices behind a row of wing were made to examine mainly the shape and strength of those. Results show that the V- and W-component of mean velocity is produced by the trailing vortex, and that the secondary currents generated by those vortices direct downwards at the mid-span of wings, while upwards at the middle between the wings. The vortex wandering phenomenon is observed by the secondary flow vectors. The strength of trailing vortex increases with the attack angle. Author

**N86-15241** Old Dominion Univ., Norfolk, Va.

**STUDIES ON THE INTERFERENCE OF WINGS AND PROPELLER SLIPSTREAMS Ph.D. Thesis**

R. PRABHU 1985 114 p Previously announced as N85-17553
Avail: Univ. Microfilms Order No. DA8517782

The small disturbance potential flow theory is applied to determine the lift of an airfoil in a nonuniform parallel stream. The given stream is replaced by an equivalent stream with a certain number of velocity discontinuities, and the influence of these discontinuities is obtained by the method of images. Next, this method is extended to the problem of an airfoil in a nonuniform stream of smooth velocity profile. This model allows perturbation velocity potential in a rotational undisturbed stream. A comparison of these results with numerical solutions of Euler equations indicates that, although approximate, the present method provides useful information about the interaction problem while avoiding the need to solve the Euler equations. Author

**N86-15242#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.

**THE EXPERIMENTAL DETERMINATION OF THE SUBSONIC AERODYNAMIC CHARACTERISTICS OF AN OGIVE-CYLINDER BODY INCLUDING A COMPARISON WITH THEORETICAL ESTIMATES, VOLUME 1**

D. I. T. P. LLEWELYN-DAVIES Jun. 1985 78 p refs
(CAR-8509; ISBN-0-9477-67-24-X) Avail: NTIS HC A05/MF A01

Wind tunnel tests made on an ogive cylinder body of 6:1 fineness ratio are reported. The distribution of pressure on the body was measured over an incidence range of -1 to 10 degrees. The local loading distributions were obtained by integration of the pressure coefficients; further integration yielded the overall normal force and pitching moment coefficients and hence the center of pressure position. It is shown that the aerodynamic characteristics are very sensitive to conditions in the base region and that unexpectedly large loadings are present over the last 10% of the body length. It is indicated that the bluff asymmetric model support system may be the source of some additional interference effects at the higher incidences, even though it is some 3.7 body diameters downstream of the base. The experimental results are compared with theoretical estimates obtained by an inviscid ring-source method of estimation for axisymmetrical bodies. E.A.K.

**N86-15243*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**PERFORMANCE AND LOADS DATA FROM A HOVER TEST OF A FULL-SCALE XV-15 ROTOR**

F. F. FELKER, M. D. BETZINA, and D. B. SIGNOR Nov. 1985 97 p refs

(NASA-TM-86833; REPT-85404; NAS 1.15:86833) Avail: NTIS HC A05/MF A01 CSCL 01A

A hover test of a full-scale XV-15 rotor was conducted at the Outdoor Aerodynamic Research Facility at Ames Research Center. The primary objective of the test was to obtain accurate measurements of the hover performance of the original, metal-blade XV-15 rotor system. Data were acquired for rotor tip Mach numbers ranging from 0.60 to 0.73. This report presents data on rotor performance, rotor wake downwash velocities, and rotor loads. Author

**N86-15244*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**RELATIVE ADVANTAGES OF THIN-LAYER NAVIER-STOKES AND INTERACTIVE BOUNDARY-LAYER PROCEDURES**

U. MEHTA, K. C. CHANG (Douglas Aircraft Co., Long Beach, Calif.), and T. CEBECI (Douglas Aircraft Co., Long Beach, Calif.) Nov. 1985 52 p refs

(NASA-TM-86778; A-85346; NAS 1.15:86778) Avail: NTIS HC A04/MF A01 CSCL 01A

Numerical procedures for solving the thin-shear-layer Navier-Stokes equations and for the interaction of solutions to inviscid and boundary-layer equations are described and evaluated. To allow appraisal of the numerical and fluid dynamic abilities of the two schemes, they have been applied to one airfoil as a function of angle of attack at two slightly different Reynolds numbers. The NACA 0012 airfoil has been chosen because it allows comparison with measured lift, drag, and moment and with surface-pressure distributions. Calculations have been performed with algebraic eddy-viscosity formulations, and they include consideration of transition. The results are presented in a form that allows easy appraisal of the accuracy of both procedures and of the relative costs. The interactive procedure is computationally efficient but restrictive relative to the thin-layer Navier-Stokes procedure. The latter procedure does a better job of predicting drag than does the former. In both procedures, the location of transition is crucial for accurate or detailed computations, particularly at high angles of attack. When the upstream influence of pressure field through the shear layer is important, the thin-layer Navier-Stokes procedure has an edge over the interactive procedure. Author

**N86-15245*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**HYPERSONIC CHARACTERISTICS OF AN ADVANCED AEROSPACE PLANE AT MACH 20.3**

R. S. MCCANDLESS Dec. 1985 28 p refs

(NASA-TM-86435; L-15953; NAS 1.15:86435) Avail: NTIS HC A03/MF A01 CSCL 01A

Wind-tunnel studies have been performed in the Langley Hypersonic Helium Tunnel Facility to obtain static longitudinal and lateral-directional aerodynamic characteristics of an advanced aerospace plane concept. The nominal test conditions are a Mach number of 20.3 and a Reynolds number of 6.8 x 10 to the 6th power per foot at angles of attack from 0 to 25 deg and angles of sideslip of -3 and 0 deg. Stability and control characteristics are obtained for several deflections of the elevators, elevons, and rudder. In addition, a modified canopy is examined. The results indicate that this vehicle is longitudinally stable at angles of attack near the maximum lift-drag ratio. Also, the vehicle is shown to be directionally unstable with positive dihedral effect. Author

**N86-15246*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A CONSISTENT SPATIAL DIFFERENCING SCHEME FOR THE TRANSONIC FULL-POTENTIAL EQUATION IN THREE DIMENSIONS**

S. D. THOMAS and T. L. HOLST Dec. 1985 18 p refs

(NASA-TM-86716; REPT-85213; NAS 1.15:86716) Avail: NTIS HC A02/MF A01 CSCL 01A

A full-potential steady transonic wing flow solver has been modified so that freestream density and residual are captured in regions of constant velocity. This numerically precise freestream consistency is obtained by slightly altering the differencing scheme without affecting the implicit solution algorithm. The changes chiefly affect the fifteen metrics per grid point, which are computed once and stored. With this new method, the outer boundary condition is captured accurately, and the smoothness of the solution is especially improved near regions of grid discontinuity. Author

**N86-15247*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**SEPARATED TRANSONIC AIRFOIL FLOW CALCULATIONS WITH A NONEQUILIBRIUM TURBULENCE MODEL**

L. S. KING and D. A. JOHNSON Nov. 1985 20 p refs

(NASA-TM-86830; A-85397; NAS 1.15:86830) Avail: NTIS HC A02/MF A01 CSCL 01A

Navier-Stokes transonic airfoil calculations based on a recently developed nonequilibrium, turbulence closure model are presented for a supercritical airfoil section at transonic cruise conditions and for a conventional airfoil section at shock-induced stall conditions. Comparisons with experimental data are presented which show that this nonequilibrium closure model performs significantly better than the popular Baldwin-Lomax and Cebeci-Smith equilibrium algebraic models when there is boundary-layer separation that results from the inviscid-viscous interactions. Author

**N86-15248*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**INVESTIGATION OF A SUPERSONIC CRUISE FIGHTER MODEL FLOW FIELD**

D. E. REUBUSH and E. A. BARE Nov. 1985 150 p refs

(NASA-TM-86361; L-15884; NAS 1.15:86361) Avail: NTIS HC A07/MF A01 CSCL 01A

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to survey the flow field around a model of a supersonic cruise fighter configuration. Local values of angle of attack, side flow, Mach number, and total pressure ratio were measured with a single multi-holed probe in three survey areas on a model previously used for nacelle/nozzle integration investigations. The investigation was conducted at Mach numbers of 0.6, 0.9, and 1.2, and at angles of attack from 0 deg to 10 deg. The purpose of the investigation was to provide a base of experimental data with which theoretically determined data can be compared. To that end the data are presented in tables as well as graphically, and a complete description of the model geometry is included as fuselage cross sections and wing span stations. Measured local angles of attack were generally greater than free stream angle of attack above the wing and generally smaller below. There were large spanwise local angle-of-attack and side flow gradients above the wing at the higher free stream angles of attack.

**N86-15249*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**FUNDAMENTAL STUDY OF FLOW FIELD GENERATED BY ROTORCRAFT BLADES USING WIDE-FIELD SHADOWGRAPH**

S. P. PARTHASARATHY, Y. I. CHO, and L. H. BACK 1 Oct. 1985 41 p refs

(Contract NAS7-918)

(NASA-CR-176443; JPL-PUB-85-64; NAS 1.26:176443) Avail: NTIS HC A03/MF A01 CSCL 01A

The vortex trajectory and vortex wake generated by helicopter rotors are visualized using a wide-field shadowgraph technique. Use of a retro-reflective Scotchlite screen makes it possible to investigate the flow field generated by full-scale rotors. Tip vortex trajectories are visible in shadowgraphs for a range of tip Mach number of 0.38 to 0.60. The effect of the angle of attack is substantial. At an angle of attack greater than 8 degrees, the visibility of the vortex core is significant even at relatively low tip Mach numbers. The theoretical analysis of the sensitivity is carried out for a rotating blade. This analysis demonstrates that the sensitivity decreases with increasing dimensionless core radius and increases with increasing tip Mach number. The threshold value of the sensitivity is found to be 0.0015, below which the vortex core is not visible and above which it is visible. The effect of the optical path length is also discussed. Based on this investigation, it is concluded that the application of this wide-field shadowgraph technique to a large wind tunnel test should be feasible. In addition, two simultaneous shadowgraph views would allow three-dimensional reconstruction of vortex trajectories. Author

**N86-15250#** Rensselaer Polytechnic Inst., Troy, N.Y. Dept. of Materials Engineering.

**EARLY TRANSONIC IDEAS IN THE LIGHT OF LATER DEVELOPMENTS**

J. D. COLE 6 Aug. 1985 42 p
(Contract AF-AFOSR-0155-82)
(AD-A159101; AFOSR-85-0694TR) Avail: NTIS HC A03/MF A01 CSCL 20D

A survey is given of early ideas about transonic flow and their current interpretation. GRA

**N86-15251#** Royal Aircraft Establishment, Farnborough (England).

**A RAPID METHOD FOR ESTIMATING EQUIVALENT PARABOLIC POLARS FROM WIND-TUNNEL TESTS**

D. E. LEAN and S. P. FIDDES Apr. 1985 19 p
(AD-A159559; RAE-TM-AERO-2034; DRIC-BR-96601) Avail: NTIS HC A02/MF A01 CSCL 14B

A method for obtaining a best-fit parabolic drag polar from measured force results is presented. The method is used in estimating the blockage correction due to separated flow that must be applied to wind tunnel results. An important part of the method is the use of computer graphics to identify the part of the measured drag polar that may best be described by a parabola, and thus used as the basis for a curve fit. The method is fast, when compared to existing curve-fitting techniques, and suited to use with an online data reduction system. GRA

**N86-15252#** Institut Franco-Allemand de Recherches, St. Louis (France).

**VORTICES AND PRESSURE WAVES AT TRAILING EDGES**

F. SEILER and J. SRULIJES 16 Aug. 1984 10 p refs Presented at 16th International Congress on High Speed Photography and Photonics, Strasbourg, France, 27-31 Aug. 1984
(ISL-CO-224/84) Avail: NTIS HC A02/MF A01

Shock tube experiments using differential interferometry were carried out to investigate compressible subsonic flows around and behind flat plates and cylinders. Pictures taken at framing speeds up to 2 million frames/sec second and streak records show that the trailing edge vortex separation induces pressure waves moving upstream. Each vortex separation is related to the formation of a pressure wave. The flow around the bodies is influenced by the shedding frequency and is possibly coupled with the wake. After a symmetrical onset, the process of vortex separation and pressure wave generation develops into an asymmetrical wake with alternating separation. The experiments show that the dynamics of vortices close to the trailing edge is practically inviscid and incompressible. The pressure waves moving upstream must be treated as a problem of purely compressible nature. Author (ESA)

**N86-15253#** Institut Franco-Allemand de Recherches, St. Louis (France).

**DAMPING OF THE ROLLING MOTION OF FULL CALIBER FIN-STABILIZED PROJECTILES IN SUPERSONIC FLIGHT**

M. GIRAUD 21 Nov. 1984 17 p refs Presented at 8th International Symposium on Ballistics, Orlando, Fla., 23-25 Oct. 1984
(ISL-CO-233/84) Avail: NTIS HC A02/MF A01

Simultaneous measurements conducted on fin-stabilized projectiles in supersonic flight by recording the longitudinal velocity (V) with a Doppler radar and the roll velocity (p) by a radioelectric telemetering device are used to determine the variation of the roll damping moment coefficient as a function of the reduced roll velocity p/V. The variation of p/V as a function of the distance travelled is also determined. Launching the projectiles with a glide band at different initial velocities from gun barrels with different angles of twist increases the range of the reduced roll velocities in the ratio of 1 to 4. The roll damping moment coefficient varies strongly in the ratio of 1 to 8.5. In the Mach number range from 1.5 to 3.3, the action of the Mach number on the coefficient is shown. The proportionality of the roll damping moment coefficient to the reduced roll velocity is verified over the range 12 to 44 rps. Author (ESA)

**N86-15254#** Institut Franco-Allemand de Recherches, St. Louis (France).

**QUASI NONSTRETCHING HYPERVELOCITY JETS**

P. Y. CHANTERET and F. JAMET 13 Dec. 1984 11 p refs Presented at 8th International Symposium on Ballistics, Orlando, Fla., 23-25 Oct. 1984
(ISL-CO-236/84) Avail: NTIS HC A02/MF A01

The possibility to obtain high velocity shaped charge jets characterized by a very low velocity gradient is studied using one-dimensional calculations and experimental flash X-ray observations. Results show that it is possible to form high velocity jets with 0.5 km/sec velocity difference between tip and rear of the jet with a kinetic energy equivalent to that of classical stretching jets. Comparison of jets is used to discuss analytical models employed to evaluate velocities, break-up, and penetration of shaped charge jets. Author (ESA)

**N86-15256#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel Working Group 07.

**TEST CASES FOR INVISCID FLOW FIELD METHODS**

Loughton, England May 1985 336 p refs
(AGARD-AR-211; ISBN-92-835-1497-1) Avail: NTIS HC A15/MF A01

The escalating costs and the continuing limitations of wind tunnel testing together with the growing imperative to achieve the optimal design have rapidly increased the importance of computational fluid dynamics in the design of military aircraft. At relevant Reynolds numbers, inviscid flow methods continue to play an essential role in this design process. In recognition of this, the AGARD Fluid Dynamics panel established Working Group 07 to specify relevant reference test cases to serve as validation bases for those developing new methods with improved accuracy and cost-effectiveness. These cases further serve as check cases for those learning to use existing production codes. The recommendations of the Working Group are presented.

**N86-15257#** Boeing Military Airplane Development, Seattle, Wash.

**OBJECTIVES AND SCOPE OF THE WORKING GROUP 07**

H. YOSHIHARA *In* AGARD Test Cases for Inviscid Flow Field Methods 3 p May 1985
Avail: NTIS HC A15/MF A01

The objectives and scope of the working group on test cases for inviscid flow field methods are defined. The types of solutions sort and their procedures are given. The membership of the group is given, both panel and nonpanel members. Also given is the meetings procedures. E.R.

**N86-15258#** Trondheim Univ. (Norway).
**FORMULATION OF THE EULER BOUNDARY VALUE PROBLEM**
H. NORSTRUD *In* AGARD Test Cases for Inviscid Flow Field Methods 56 p May 1985 refs
Avail: NTIS HC A15/MF A01

Most of the obtained solutions to fluid flow problems are based on irrotational motion and, hence, can be grouped together as potential flow solutions. In many practical cases such potential approximations yields satisfactory results as compared to a rotational flow solution. The Mach number contours around an airfoil at supersonic speed is shown. For flows with strong entropy variation in the flow field the situation, however, is changed. This is especially true for embedded shocks. The Mach number contour around a cylinder for M sub infinity less than 1, and the corresponding streamlines are illustrated. The major reason behind the discrepancy between a rotational and irrotational solution lies in the fact that the potential flow solution does not satisfy the Rankine-Hugoniot jump condition across a shock. As it can be seen, an irrotational solution like the full potential solution or the transonic small perturbation solution (TSP), will yield a larger Mach number jump across the shock as compared to the equivalent rotational or Euler solution. Furthermore, the shock location will differ between a rotational and irrotational solution. It must be stated that for flows with complex shock patterns and for flows with inherent vorticity the method of solution adopted must be based on the Euler equations. The flow field around a modern combat aircraft is well suited to serve as an example to this. The calculated pressure distribution around an aircraft forebody at M sub infinity is shown. Author

**N86-15259#** National Aerospace Lab., Amsterdam (Netherlands).
**NUMERICAL METHODS**
J. W. BOERSTOEL *In* AGARD Test Cases for Inviscid Flow Field Methods 7 p May 1985 refs
Avail: NTIS HC A15/MF A01

A survey of numerical techniques used in computational simulations of Euler flows is presented. The number of techniques reported in literature is so large that a detailed description of all of them is out of scope. Therefore, this survey is concentrated to sketching only the more important numerical topics, and pointing out differences in possible approaches. The general approach to the numerical solution of the initial boundary value problem of the Euler equations consists of two major steps. In the first step the flow equations, the boundary conditions, and the initial conditions of the continuum-model formulation of the problem are replaced by a large system of algebraic equations (discretization). In the second step the resulting system of algebraic equations is solved (solution). The discretization process reduces to splitting the (t,x,y,z)-space into small elementary volumes called cells (grid generation), and writing down, for each cell, algebraic approximations of the conservation equations, of the initial conditions, and of boundary conditions. The solution of the algebraic equation system is discussed, and the topic of well-posedness of the numerical problem is briefly discussed. Author

**N86-15260#** Politecnico di Milano (Italy).
**EXACT SOLUTIONS TO TRANSONIC AND SUPERSONIC FLOWS**
G. CHIOCCHIA *In* AGARD Test Cases for Inviscid Flow Field Methods 14 p May 1985 refs
Avail: NTIS HC A15/MF A01

A survey of the most important analytical solutions for transonic and supersonic flows is presented. Particular attention is paid to the transonic cases, where the presence of embedded supersonic regions of a priori unknown extension causes considerable difficulties to the numerical computations and raises the need for reference test cases. Exact analytical transonic solutions are rare and not always adequate for checking practical cases. For this reason some approximate analytical solutions are also presented; in this case, however, the approximations must be well known in advance and their numerical effects must be limited. As a general standard of judgement, solutions in which the approximation consists in the replacement of partial differential equations by finite difference equations are excluded. Closed form or series solutions for two or three cases of approximate equations whose validity fields are well established are accepted. Author

**N86-15261#** National Aeronautical Establishment, Ottawa (Ontario).
**REFERENCE TEST CASES AND CONTRIBUTORS**
D. J. JONES *In* AGARD Test Cases for Inviscid Flow Field Methods 24 p May 1985 refs
Avail: NTIS HC A15/MF A01

The reference test cases are divided into two sections. They are the two dimensional airfoils and cascades and three dimensional cases. Specifications, reference solutions, and contributors are given for the two dimensional cases. Specifications are divided into planform, profiles, root sections, and tip sections for the three dimensional cases. E.R.

**N86-15262#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
**NUMERICAL SOLUTIONS OF TWO-DIMENSIONAL REFERENCE TEST CASES**
H. VIVIAND *In* AGARD Test Cases for Inviscid Flow Field Methods 68 p May 1985 refs
Avail: NTIS HC A15/MF A01

Selected numerical solutions of the two dimensional reference test cases are presented and the quality if not the absolute accuracy of these solutions are assessed. The numerical methods used to solve the Euler equations are not taken into consideration in the present discussion, and the numerical solutions available for a given test case are evaluated essentially through cross-comparisons of these solutions and by taking into account some known features of the exact (unknown) solution. The present evaluation has shown the importance of the outer boundary position in relation with the boundary conditions and the numerical treatment applied at this boundary. It seems that the minimum distance at which this boundary should be located in order to achieve a given accuracy can vary to a very large extent depending on the boundary treatment. This is an important question which requires detailed studies of all the factors involved. Whereas the trailing edge problem and the Zierep singularity problem change in nature when viscous effects are taken into account, the problem of the far field treatment (outside the viscous wake) remains exactly the same at high Reynolds numbers. Author

**N86-15263#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
**NUMERICAL SOLUTIONS FOR THREE-DIMENSIONAL CASES: SWEPT WINGS**
P. SACHER *In* AGARD Test Cases for Inviscid Flow Field Methods 110 p May 1985 refs
Avail: NTIS HC A15/MF A01

The simplest swept wing geometry of practical interest was Test Case 11 and 12, ONERA M6, with constant section, moderate Aspect Ratio = 3.8 and only 30 deg leading edge sweep. But even this simple planform produced in TC11 with 3.06 deg angle of attack the rolling up of a Tip-Vortex which may contribute to induced drag. The numerical analysis of the nonlinear wake leaving the trailing edge of a lifting wing including the rolling up at the wing tips is one of the most promising aspects of the potential of solving the Euler equations at considerably higher cost in place of Full Potential equation. Consequently the complexity of a realistic transport type planform with twist, camber, variations of section profiles and breakpoints in leading and/or trailing edge sweep can be represented by Test Case 16, NASA AMES SWEPT WING. More or less, all additional problems in computation of the flow field are due to mesh-grid generation and the increase of the number of grid points which are necessary to simulate the flow sufficiently accurate. Only one contribution was obtained for this Test Case. Author

**N86-15264#** Royal Aircraft Establishment, Farnborough (England).

**NUMERICAL SOLUTIONS FOR THREE-DIMENSIONAL CASES: DELTA WINGS**

J. H. B. SMITH *In* AGARD Test Cases for Inviscid Flow Field Methods 94 p May 1985 refs

Avail: NTIS HC A15/MF A01

Wings of delta planform present the real problems of estimating wave drag and representing vortex flows in their simplest form. Any method of calculation aiming to contribute to these problems should be capable of performing well on such simple shapes. On the other hand, there is no evidence that reliable solutions for such simple shapes already exist. It was decided to seek solutions for wings of delta planform for conditions which are relevant to wave-drag estimation and vortex-flow prediction. For a shape which is reasonably slender, at a Mach number sufficiently greater than unity, the flow is supersonic everywhere, so that there is no upstream influence, and the flow can, in principle, be calculated by a space marching method. The final considerations affecting the choice of case are that the shape should be simple, and that experimental measurements should exist. The first makes it easy to ensure that the description of the shape is complete and unambiguous, and makes it possible for all potential computers to represent the shape in their programs. The second, while not strictly necessary and perhaps even irrelevant to the assessment of the accuracy of inviscid calculations, does provide an assurance that solutions judged to be mathematically accurate are not in serious conflict with physical reality. Author

**N86-15265#** Boeing Military Airplane Development, Seattle, Wash.

**CONCLUDING REMARKS Abstract Only**

H. YOSHARA *In* AGARD Test Cases for Inviscid Flow Field Methods 1 p May 1985

Avail: NTIS HC A15/MF A01

It may be recalled that the primary purpose of the WG07 was the generation of relevant Euler solutions, both planar and 3D, to serve as Reference Test Cases which developers of Euler methods could use to assess their codes. Since such Reference Test Cases in most cases must themselves be generated numerically, there was initial concern as to the meaningfulness of this objective. The quality of the results produced by the many dedicated contributors has largely dispelled this concern. Except for a few instances, the numerical algorithms used by the contributors within the flow field and at the boundaries were sound. The relative accuracies of the various contributions were due in large part to the density and extent of the mesh used, though the quality of the artificial viscosity used was also an important factor. The planar airfoil solutions recommended herein should serve as reliable Reference Test Cases. The 3D cases understandably are relatively less reliable and must at present be considered as interim Test Cases to serve as approximate guides. It is hoped that the latter cases can be upgraded by future improved calculations. To monitor such activities as well as possibly to extent the scope to viscous solutions, the AGARD Fluid Dynamics Panel has established a Computational Fluid Dynamics Subcommittee. Author

**N86-15266#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**AIRCRAFT DRAG PREDICTION AND REDUCTION**

Loughton, England Jul. 1985 269 p refs Special course held in Rhode-Saint-Genese, Belgium, 20-23 May 1985 and in Hampton, Va., 5-8 Aug. 1985; sponsored by von Karman Inst. and AGARD

(AGARD-R-723; ISBN-92-835-1507-2) Avail: NTIS HC A12/MF A01

Numerous topics relating to aircraft drag prediction and control are discussed. Laminar flow control with suction; parasitic and interference drag prediction and reduction; and vortex drag reduction are among the topics discussed.

**N86-15267#** Lockheed-Georgia Co., Marietta. Advanced Flight Sciences.

**AIRCRAFT DRAG REDUCTION TECHNOLOGY: A SUMMARY**

A. S. THOMAS *In* AGARD Aircraft Drag Prediction and Reduction 20 p Jul. 1985 refs Previously announced as N85-16782

Avail: NTIS HC A12/MF A01

The current techniques of aircraft viscous drag reduction and some of the more recent developments that have taken place in this technology are reviewed. The various sources and relative contributions of aircraft drag are described including skin friction drag, pressure drag, interference drag and lift induced drag. The physical processes that lead to these drag contributions are emphasized and methods of reducing the impact of these drag sources are discussed. It is shown how innovative and optimized aircraft configurations can lead to drag benefits. E.A.K. (IAA)

**N86-15268#** Arizona State Univ., Tempe. Mechanical and Aerospace Engineering.

**BOUNDARY-LAYER TRANSITION: T-S WAVES AND CROSSFLOW MECHANISMS**

W. S. SARIC *In* AGARD Aircraft Drag Prediction and Reduction 18 p Jul. 1985 refs

Avail: NTIS HC A12/MF A01

The basic instability mechanisms are discussed from an elementary standpoint considering only boundary layers in external flows. The current state-of-the-art of boundary-layer transition prediction is reviewed and, by using recent results, it is shown that a number of unique transition mechanisms exist and each can play a different role in the breakdown to turbulence. The control of the stability and transition characteristics of a particular flow field requires thoroughly understanding the details of these breakdown mechanisms. Author

**N86-15269#** Arizona State Univ., Tempe. Mechanical and Aerospace Engineering.

**LAMINAR FLOW CONTROL WITH SUCTION: THEORY AND EXPERIMENT**

W. S. SARIC *In* AGARD Aircraft Drag Prediction and Reduction 11 p Jul. 1985 refs

Avail: NTIS HC A12/MF A01

The concept of boundary-layer stabilization with weak wall suction is introduced at a basic level and the means for calculating the effects of suction are described. The historical development of this technique is reviewed and the state-of-the-art of theory and experiment is covered. Some problems associated with the implementation of suction into aircraft boundary layers are discussed. Author

**N86-15270*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DESIGN CONSIDERATIONS FOR APPLICATION OF LAMINAR FLOW CONTROL SYSTEMS TO TRANSPORT AIRCRAFT**

A. L. BRASLOW and M. C. FISCHER *In* AGARD Aircraft Drag Prediction and Reduction 27 p Jul. 1985 refs

Avail: NTIS HC A12/MF A01 CSCL 01A

The current status of the laminar-flow control LFC technology is summarized. Factors that have previously inhibited the application of LFC are first reviewed. Involved are the effects of atmospheric ice crystals, surface irregularities, acoustical environment, and off-design operating conditions. Aircraft design trends that are different from turbulent aircraft are discussed as are various design requirements unique to the LFC systems. Current design approaches for the principal LFC systems are reviewed. These include the system for protection of the leading-edge region from surface contamination and icing and the system for removal of a portion of the boundary-layer air. The latter includes consideration of both multiple spanwise suction slots and distributed perforations and required differences between the wing-box and leading-edge box regions. Author

**N86-15271*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**TURBULENT DRAG REDUCTION FOR EXTERNAL FLOWS**
D. M. BUSHNELL *In* AGARD Aircraft Drag Prediction and Reduction 26 p Jul. 1985 refs
Avail: NTIS HC A12/MF A01

A summary of turbulent drag reduction approaches applicable to external flows is given. Because relatively recent and exhaustive reviews exist for laminar flow control and polymer (hydrodynamic) drag reduction, the focus here is upon the emerging areas of nonplanar geometry and large-eddy alteration. Turbulent control techniques for air generally result in modest (but technologically significant) drag reductions (order of 20 percent or less), whereas hydrodynamic approaches can yield drag reductions the order of 70 percent. Suggestions are included for alternative concepts and optimization of existing approaches. Author

**N86-15272#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
**PARASITIC AND INTERFERENCE DRAG PREDICTION AND REDUCTION**
P. POISSON-QUINTON *In* AGARD Aircraft Drag Prediction and Reduction 27 p Jul. 1985 refs
Avail: NTIS HC A12/MF A01

Parasitic drag related to excrescences, leaks, etc., and to local flow separations, and interference drag related to wing/fuselage, propulsive nacelle/wing or fuselage, and external stores/wing or fuselage, etc., are discussed. Although a precise prediction of such drag terms is still difficult to obtain in wind-tunnel testing, a large number of typical trends are available to the designer to avoid too large penalties on transport or combat aircraft at the preliminary design stage; several examples are given to illustrate these trends, together with some optimization methods. Author

**N86-15273#** Lockheed-Georgia Co., Marietta.
**RECENT DEVELOPMENTS IN THREE-DIMENSIONAL WAKE ANALYSIS**
J. E. HACKETT and A. SUGAVANAM *In* AGARD Aircraft Drag Prediction and Reduction 19 p Jul. 1985 refs
Avail: NTIS HC A12/MF A01

Significant advances in the determination of drag and its components (viscous, vortex, source, blockage, etc.) have been made in recent years. These were triggered by the reduction of the vortex drag integral to a wake integral by Maskell in the early 1970's. In 1979, Wu Hackett, and Lilley broadened the basis for Maskell's results and, in 1984, Hackett and Sugavanam devised methods which make it suitable for use in the near-wake of wind tunnel models. These advances are reviewed. A consistent derivation, starting from a simple form of the momentum equations, which include the best and least restrictive assumptions and procedures is provided. A practical example is discussed. Author

**N86-15274#** Royal Aircraft Establishment, Farnborough (England).
**PREDICTION OF THE DRAG OF WINGS AT SUBSONIC SPEEDS BY VISCOUS/INVISCID INTERACTION TECHNIQUES**
R. C. LOCK *In* AGARD Aircraft Drag Prediction and Reduction 71 p Jul. 1985 refs
Avail: NTIS HC A12/MF A01

Alternative ways of calculating the drag of an aerofoil or wing are discussed, and it is concluded that, at the present time, the far field approach is both more accurate and more informative. In this approach, the total drag is split into three components, wave (C sub D sub W), vortex (C sub D sub i) and viscous (C sub D sub V), and it is shown how simple methods for estimating these components can be derived. A brief account is given of the modern technique of viscous-inviscid interaction, concentrating on methods in which an accurate inviscid code is coupled with an integral method for calculating the viscous shear layers (boundary layer and wake). Recent advances are described which should improve the overall accuracy and allow more difficult cases, where boundary layer separation is present, to be treated successfully. Some methods of this type for aerofoils in two dimensions are summarized, and their accuracy assessed by comparison with experiment, including examples where flow separation takes place. Finally, an experiment on a particular wing-body combination, typical of a modern transport aircraft design, is chosen to show how an analysis of the drag can be performed by using the experimental pressure distribution as input to theoretical methods for calculating the separate wave, vortex and viscous components of drag. Author

**N86-15275#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Institut fuer Experimentelle Stroemungsmechnik.
**TRANSONIC DRAG RISE AND DRAG REDUCTION BY ACTIVE/PASSIVE BOUNDARY LAYER CONTROL**
E. STANEWSKY and F. KROGMANN *In* AGARD Aircraft Drag Prediction and Reduction 41 p Jul. 1985 refs
Avail: NTIS HC A12/MF A01

Accurate drag prediction and efficient drag reduction are, particularly in the transonic speed range, paramount to the future of economical aircraft design and operation. The prediction of drag based on high-speed wind tunnel results are discussed with emphasis placed on problems associated with testing at transonic speeds and the transfer of low Reynolds number wind tunnel results to full-scale aircraft conditions. A more general consideration of the drag development associated with compressibility and viscosity and the viscous-inviscid interaction of the flow on an aerodynamic configuration is given. Drag reduction methods which are mainly based on active and passive boundary layer control by means of slots and perforated strips utilized to either draw material from and/or add material to the boundary layer are discussed. It may be concluded that present transonic drag predicton methods need further improvement, especially at off-design conditions; and that some of the approaches to boundary layer control considered may be quite efficient in increasing aircraft aerodynamic performance. Author

**N86-15287*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**LIFTING SURFACE THEORY FOR A HELICOPTER ROTOR IN FORWARD FLIGHT**
H. TAI and H. L. RUNYAN *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 89-101 Nov. 1985 refs Previously announced as N85-10916
Avail: NTIS HC A21/MF A01

A lifting surface theory was developed for a helicopter rotor in forward flight for compressible and incompressible flow. The method utilizes the concept of the linearized acceleration potential and makes use of the vortex lattice procedure. Calculations demonstrating the application of the method are given in terms of the lift distribution on a single rotor, a two-bladed rotor, and a rotor with swept-forward and swept-back tips. In addition, the lift on a rotor which is vibrating in a pitching mode at 4/rev is given. Compressibility effects and interference effects for a two-bladed rotor are discussed. Author

**N86-15288*#** Hughes Helicopters, Culver City, Calif.
**DEVELOPMENT OF AN UNSTEADY AERODYNAMICS MODEL TO IMPROVE CORRELATION OF COMPUTED BLADE STRESSES WITH TEST DATA**
S. T. GANGWANI *In* NASA. Ames Research Center Rotorcraft Dynamics 11984 p 103-116 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01A

A reliable rotor aeroelastic analysis operational that correctly predicts the vibration levels for a helicopter is utilized to test various unsteady aerodynamics models with the objective of improving the correlation between test and theory. This analysis called Rotor Aeroelastic Vibration (RAVIB) computer program is based on a frequency domain forced response analysis which utilizes the transfer matrix techniques to model helicopter/rotor dynamic systems of varying degrees of complexity. The results for the AH-1G helicopter rotor were compared with the flight test data during high speed operation and they indicated a reasonably good correlation for the beamwise and chordwise blade bending moments, but for torsional moments the correlation was poor. As a result, a new aerodynamics model based on unstalled synthesized data derived from the large amplitude oscillating airfoil experiments was developed and tested. Author

**N86-15289*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AEROELASTIC CONSIDERATIONS FOR TORSIONALLY SOFT ROTORS**
W. R. MANTAY and W. T. YEAGER, JR. *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 117-136 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01A

A research study was initiated to systematically determine the impact of selected blade tip geometric parameters on conformable rotor performance and loads characteristics. The model articulated rotors included baseline and torsionally soft blades with interchangeable tips. Seven blade tip designs were evaluated on the baseline rotor and six tip designs were tested on the torsionally soft blades. The designs incorporated a systemmatic variation in geometric parameters including sweep, taper, and anhedral. The rotors were evaluated in the NASA Langley Transonic Dynamics Tunnel at several advance ratios, lift and propulsive force values, and tip Mach numbers. A track sensitivity study was also conducted at several advance ratios for both rotors. Based on the test results, tip parameter variations generated significant rotor performance and loads differences for both baseline and torsionally soft blades. Author

**N86-15293*#** Indian Inst. of Science, Bangalore. Dept. of Aeronautical Engineering.
**A REVIEW OF DYNAMIC INFLOW AND ITS EFFECT ON EXPERIMENTAL CORRELATIONS**
G. H. GAONKAR and D. A. PETERS (Washington Univ., St. Louis, Mo.) *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 187-205 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01A

A review is given of the relationship between experimental data and the development of modern dynamic-inflow theory. Some of the most interesting data, first presented 10 years ago at the Dynamic Specialist's Meeting, is now reviewed in light of the newer theories. These pure blade-flapping data correlate very well with analyses that include the new dynamic inflow theory, thus verifying the theory. Experimental data are also presented for damping with coupled inplane and body motions. Although inclusion of dynamic inflow is often required to correlate this coupled data, the data cannot be used to verify any particular dynamic inflow theory due to the uncertainties in modeling the inplane degree of freedom. For verification, pure flapping is required. However, the coupled data do show that inflow is often important in such computations. Author

**N86-15298*#** Howard Univ., Washington, D. C.
**DYNAMIC RESPONSE CHARACTERISTICS OF A CIRCULATION CONTROL ROTOR MODEL PNEUMATIC SYSTEM**
C. B. WATKINS, K. R. READER (Naval Ship Research and Development Center, Bethesda, Md.), and S. K. DUTTA *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 273-285 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01B

Numerical and experimental simulation of unsteady airflow through the control valve and slotted air duct of a circulation control rotor is described. The numerical analysis involves the solution of the quasi-one-dimensional compressible fluid-dynamic equations in the blade air duct together with the coupled isentropic flow equations for flow into the blade through the valve and out of the blade through the Coanda slot. Numerical solutions are compared with basic experimental results obtained for a mockup of a circulation control rotor and its pneumatic valving system. The pneumodynamic phenomena that were observed are discussed with particular emphasis on the characteristic system time lags associated with the response of the flow variables to transient and periodic control valve inputs. Author

# 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-17063**
**LONG TAXI ROLLS CAN LEAD TO CATASTROPHIC BLOW-OUTS**
S. N. BOBO (DOT, Transportation Systems Center, Cambridge, MA) ICAO Bulletin, vol. 40, Oct. 1985, p. 34-37.

Airliner takeoff taxi run distances of more than 5.5 km lead to landing gear tire states at which, especially in the case of wide body aircraft, the tires begin to rapidly degrade. This increases the likelihood of blowouts, with catastrophic effects. Attention is given to tire temperature rise over long taxi rolls for various operational conditions, and to safety enhancement recommendations encompassing reductions of takeoff loads and taxi speeds. O.C.

**A86-17174**
**AIRLINE EFFICIENCY**
J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 128, Nov. 2, 1985, p. 32-36.

An attempt is made to accurately characterize the comparative efficiency of operations for a sample of 14 airlines whose schedules include both short and long range flights. The tabulations made of their performance range over such aspects of operation as average route length, departures per aircraft, departures per employee, output per employee, revenue rate and revenue per employee, passengers per employee, aircraft utilization, flying hours per employee, and overall cost levels. Total capacity tonne-km is employed as the ultimate measure of transport efficiency. O.C.

**A86-18406**
**FAA CERTIFICATION OF ROTORCRAFT ENGINE INDUCTION SYSTEM FOR ICE PROTECTION**
H. R. WHITLOCK (FAA, Aircraft Certification Div., Fort Worth, TX) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Attention is given to the methodology required for demonstration of compliance with Federal Aviation Regulations FAR 27.1093(b) and FAR 29.1093(b), which require that helicopter engine induction systems operate throughout the aircraft/engine design envelope without the accumulation of ice that might adversely effect engine operations. The present discussion notes the variety of engine air intakes for which these requirements must be met. Dry air tests, tanker and spray rig tests, icing tunnel tests, and natural icing tests, together with the type of flight data required and the instrumentation that furnishes it, are discussed. O.C.

**A86-18452**
**ANALYTICAL METHODS FOR LHX MISSION AND TASK ANALYSIS**
B. E. HAMILTON and H. P. HARPER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 9 p.

Attention is given to a methodology by means of which the aircrew workload of a novel aircraft design can be predicted, on the basis of attentional demand and task times for up to three simultaneous tasks. The predictions, in terms of 'acceptable', 'marginal', or 'unacceptable' ratings, are amenable to empirical validation. As decisions are made on the basis of previously defined rules, changes in analyst understanding or work overload management philosophy can be readily implemented for subsequent validation. O.C.

**A86-18454**
**MANNED SIMULATION STUDIES OF AIRCREW WORKLOAD IN THE F-15 DUAL ROLE FIGHTER**
W. J. CODY (McDonnell Douglas Corp., St. Louis, MO) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 36 p.

A man-in-the-loop flight simulation program has been conducted in support of the F-15 Dual Role Fighter derivative, with a view to crew station configuration refinement and the demonstration of manageability in anticipated aircrew workloads for various mission scenarios. The results obtained in the first phase of the simulation program led to changes in the baseline hardware configuration, information displays, and operating procedures; these changes were then tested during a second phase. Crew workload was quantified in terms of predefined mission performance criteria, and was examined under both fully operational and degraded system conditions. O.C.

**A86-18843**
**INJURY PATTERN ANALYSIS OF HELICOPTER WIRE STRIKE ACCIDENTS (+GZ LOAD)**
W. D. FARR (U.S. Army, Brooke Army Medical Center, San Antonio, TX), C. J. RUEHLE, G. N. WAGNER (Armed Forces Institute of Pathology, Div. of Aerospace Pathology, Washington, DC), and D. M. POSEY (U.S. Army, Tripler Army Medical Center, HI) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 56, Dec. 1985, p. 1216-1219. refs

Injury patterns in rotary wing aircraft wire strike accidents were reviewed to determine mechanisms of injury. It was found that U.S. Army Safety Center data showed that between January 1, 1974 and August 31, 1981 there were 167 wire strikes involving Army helicopters which resulted in 60 injuries and 34 fatalities. From December 13, 1978 to June 23, 1982, three types of rotary wing aircraft were in eight fatal accidents. These mishaps accounted for 28 casualities: 14 fatalities and 14 injuries. Aviators comprised 64.4 percent of the fatalities. Injury pattern analysis showed 100 percent had major head and neck injuries with 66 percent having basilar skull fractures. Two-thirds had associated mandibular fractures or evidence of impact forces transmitted through the mandible to the skull. The same number had wedge-shaped chin lacerations from impact with the cyclic control stick. Transmission of lethal impact forces primarily in the +Gz direction through the mandible to the skull is postulated. This suggests either improper use and/or failure of the seat and restraint systems. Author

**A86-19069#**
**INFLUENCE OF THE DROPPING CONDITIONS ON CONTAINER MOTION NEAR THE CARRIER AND ON THE IMPACT PARAMETERS [WALYW WARUNKOW ZRZUTU NA RUCH ZASOBNIKA W POBLIZU NOSICIELA I PARAMETRY UPDADKU]**
J. MARYNIAK, K. MICHALEWICZ, and Z. WINCZURA (Warszawa, Politechnika, Warsaw, Poland) Mechanika Teoretyczna i Stosowana (ISSN 0079-3701), vol. 22, no. 3-4, 1984, p. 433-443. In Polish. refs

The features of flight of a container dropped from a subsonic aircraft were studied. Container dynamics at the dropping point as well as the influence of the initial conditions on the flight parameters near the impact point were evaluated. The container was considered as a rigid object having six degrees of freedom. Exemplary numerical calculations were performed. It was found that a small divergence from the assumed dropping conditions leads to the significant deviation of the impact point. Author

**N86-14258** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Transport Research Dept.
**THE EFFECT OF SUPPLY PARAMETERS ON THE VOLUME OF FUTURE AIRCRAFT MOVEMENTS**
E. URBATZKA 1985 6 p Presented at WCTR '83 Conf., Hamburg, West Germany, 26-29 Apr. 1983
Avail: Issuing Activity

A method for estimating future volumes of aircraft movements for airport planning is described. It requires a route specific analysis of passenger load factor, aircraft mixture (and thus seats per flight), and flight frequency. The method is unsuitable for computerization. For each route domestic and foreign air transport policies; past, present and future demand; development and structure of supply; the development of aircraft fleets of airlines involved, and the world aircraft market must be considered. Author (ESA)

**N86-14259#** Dayton Univ., Ohio.
**FINITE ELEMENT ANALYSIS OF SOFT-BODY IMPACT Final Report, Sep. 1982 - Mar. 1984**
R. A. BROCKMAN Oct. 1984 106 p
(Contract F33615-82-K-3408)
(AD-A158436; UDR-TR-84-09; AFWAL-TR-84-3035) Avail: NTIS HC A06/MF A01 CSCL 20A

This report describes the development of analytical and numerical methods for determining the dynamic structural response caused by soft body impact. The prediction of stress and deflection behavior of aircraft transparencies due to collisions with birds is the primary area of application. When the structure is relatively flexible, such an impact involves strong coupling between the dynamic motion of the colliding bodies. The developed techniques use appropriate finite element methods in each region, together with a contact solution algorithm, to compute the coupled structural response, while the soft-body motions are integrated using a simpler explicit technique. The soft body dynamic analysis uses a Lagrangian description to track the free surface and impact region accurately, with an automatic rezoning procedure to correct large mesh distortions. GRA

**N86-14260#** Federal Aviation Administration, Washington, D.C. Office of Civil Aviation Security.
**EFFECTIVENESS OF THE CIVIL AVIATION SECURITY PROGRAM Semiannual Report, 1 Jul. - 31 Dec. 1984**
12 Apr. 1985 20 p
(AD-A159511; FAA-ACS-84-2-21; SAR-21) Avail: NTIS HC A02/MF A01 CSCL 01B

This report provides details on the effectiveness of security screening of passengers and all property intended to be carried in the aircraft cabin in air transportation or intrastate air transportation. It also provides a statistical summary of aircraft hijackings and alleged violations of Federal Aviation regulations pertaining to security screening. GRA

**N86-14261#** Luftfahrt-Bundesamt, Brunswick (West Germany). Flugunfalluntersuchungsstelle.
**RESULTS OF THE EXPERT STUDY OF ACCIDENTS DURING OPERATION OF GERMAN AIRCRAFT IN THE HOMELAND AND ABROAD AS WELL AS OF FOREIGN AIRCRAFT IN THE HOMELAND Annual Report, 1980 [ERGEBNISSE DER FACHLICHEN UNTERSUCHUNG VON UNFAELLEN BEI DEM BETRIEB DEUTSCHER LUFTFAHRZEUGE IM IN- UND AUSLAND SOWIE AUSLAENDISCHE LUFTFAHRZEUGE IM INLAND]**
Mar. 1985 116 p In GERMAN
Avail: NTIS HC A06/MF A01

Aircraft accidents which occurred during 1980 are listed. Aircraft categories (transport aircraft; helicopters, gliders; parachutes; balloons, other) causes; aircraft accident distribution; types of operations or flights during which the accidents occurred; and severity (casualities, injuries), are reported. Author (ESA)

**N86-14262#** Luftfahrt-Bundesamt, Brunswick (West Germany). Flugunfalluntersuchungsstelle.
**RESULTS OF THE EXPERT STUDY OF ACCIDENTS DURING OPERATION OF GERMAN AIRCRAFT IN THE HOMELAND AND ABROAD AS WELL AS OF FOREIGN AIRCRAFT IN THE HOMELAND Annual Report, 1981 [ERGEBNISSE DER FACHLICHEN UNTERSUCHUNG VON UNFAELLEN BEI DEM BETRIEB DEUTSCHER LUFTFAHRZEUGE IM IN- UND AUSLAND SOWIE AUSLAENDISCHE LUFTFAHRZEUGE IM INLAND]**
Apr. 1985 125 p In GERMAN
Avail: NTIS HC A06/MF A01

Aircraft accidents which occurred during 1981 are listed. Aircraft categories (transport aircraft, helicopters, gliders; parachutes; balloons; other) causes; aircraft accident distribution; types of operations or flights during which the accidents occurred; and severity (casualties, injuries) are given. Author (ESA)

**N86-14263#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
**FUEL SAVING BY OPTIMAL INTEGRATION OF ON-BOARD AVIONICS AND AIR TRAFFIC CONTROL**
J. M. TENHAVEN Apr. 1984 23 p refs Submitted for publication
(NLR-MP-84035-U; B8566435; AD-B094318L) Avail: NTIS HC A02/MF A01

The possibilities for airlines to cut operating costs by ensuring that aircraft follow the most energy efficient flight plans are discussed. The role of air traffic control is explained, and benefits from developments such as flight management systems and secondary surveillance radar are considered. Author (ESA)

**N86-14264#** General Accounting Office, Washington, D. C. Resources Community and Economic Development Div.
**COMPILATION AND ANALYSIS OF THE FEDERAL AVIATION ADMINISTRATION'S INSPECTION OF A SAMPLE OF COMMERCIAL AIR CARRIERS**
2 Aug. 1985 157 p
(PB85-241198; GAO/RCED-85-157; B-219729) Avail: NTIS HC A08/MF A01 CSCL 01C

A compilation and analysis of data concerning the Federal Aviation Administration's (FAA's) inspection of 92 of the approximately 500 of the nation's scheduled commercial air carriers are given. These data are representative of FAA's inspections of about 350 air carriers during fiscal year 1984. This review was directed at FAA's responsibility under the Federal Aviation Act, as amended (49 U.S.C. 1421), to monitor and inspect air carrier operations and maintenance to assure compliance with federal safety regulations and FAA-approved air carrier policies and procedures. FAA's avionics, maintenance, and operations inspectors implement this responsibility by conducting inspections of air carrier personnel, aircraft, and maintenance and other facilities. Information is given on the type, frequency, and results of FAA's fiscal year 1984 air carrier inspections. GRA

**N86-15276#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
**AIRCRAFT ACCIDENT REPORT: VIEQUES AIR LINK, INC., BRITTEN-NORMAN BN-21-6 ISLANDER, N589SA, VIEQUES, PUERTO RICO, AUGUST 2, 1984**
27 Sep. 1985 51 p
(PB85-901408; NTSB/AAR-85/08) Avail: NTIS HC A04/MF A01

About 0805 Atlantic standard time on August 2, 1984, Vieques Air Link, Inc., Flight 901A, a Britten-Norman BN-2A-6 Islander, crashed into the ocean shortly after takeoff from Vieques, Puerto Rico. Flight 901A was operated from Vieques, Puerto Rico, to St. Croix, U.S. Virgin Islands. The pilot and his eight passengers were killed, and the airplane was destroyed on impact with the water. The left engine lost power shortly after takeoff and the pilot lost control of the airplane. The National Transportation Safety Board determines that the probable cause of the accident was the failure of the pilot to execute the emergency engine-out procedure properly shortly after takeoff following a loss of power in the left engine due to water in the airplane's fuel system, and the failure of the Puerto Rico Ports Authority to remove excess water known to be in the airport's in-ground fuel tank before conducting fueling operations. The pilot's failure to execute the engine-out procedure properly was due to his inexperience in multi-engine airplanes. Contributing to the accident were: (1) the air carrier's use of a pilot not certified for the flight; (2) the air carrier's failure to train the pilot adequately; (3) the pilot's failure to follow proper practices to detect water in the airplane's fuel tanks; (4) the out of weight and balance condition of the airplane; (5) the Federal Aviation Administration's (FAA) incorrect application of 14 CFR Part 135 Rules to commuter air carriers; and (6) the FAA's generally inadequate surveillance of the air carrier. Author

**N86-15277#** Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
**THREE-AXIS ELECTROFLUIDIC ANGULAR RATE SENSOR FOR EJECTION SEAT STEERING THRUST VECTOR CONTROL Final Report**
V. NUYEN 2 Oct. 1984 166 p
(Contract F41-400; F41-451)
(AD-A159413; NADC-85053-60) Avail: NTIS HC A08/MF A01 CSCL 17G

Three-axis electrofluidic rate sensors were fabricated to NAVAIRDEVCEN specifications by the Hamilton Standard Division of United Technologies. Three units were delivered for test and evaluation. These units met or exceeded all but one of the performance goals specified for the maximum performance ejection system. This exception was a 119 millisecond (ms) ready time instead of the 100 ms goal. The other important performance characteristics include the linear range of + or -700 deg/sec, a transport delay at 5 ms, and the capability to operate during and after an ejection acceleration profile which peaked at 12.3 g. These units are suitable for use in the thrust vector control system of an advanced escape system. They are ready for system integration and full system performance testing. GRA

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-18551**
**MODERNIZING TACTICAL C3I**
Defense Electronics (ISSN 0278-3479), vol. 17, Dec. 1985, p. 65, 67, 68, 71.

The Joint Surveillance and Target Attack Radar System (JSTARS), Joint Tactical Information Distribution System (JTIDS), and Joint Tactical Fusion (JTF) system are tactical C3I programs specifically focused on the requirements of conventional arms battlefield management for NATO forces. JSTARS encompasses radar, data processing, and communications equipment aboard a C-18 aircraft. JTIDS is to be complemented among ground combatants by the U.S. Army's Mobile Subscriber Equipment program, which will furnish corps-level combat communications networking that obviates Signal Corps personnel while improving survivability and flexibility. JTIDS will provide high capacity, jam-resistant digital data distribution. JTF correlates data from multiple sensors and sources in order to provide commanders a common perception of the battlefield. O.C.

**A86-18695**

**THE DISTURBANCE OF AIRCRAFT NAVIGATION AND COMMUNICATION SYSTEMS BY ATMOSPHERIC STATIC ELECTRICITY [PERTURBATION DES SYSTEMES DE NAVIGATION ET DE COMMUNICATION DES AERONEFS PAR L'ELECTRICITE STATIQUE ATMOSPHERIQUE]**

H. BONGRAIN Navigation (Paris) (ISSN 0028-1530), vol. 33, Oct. 1985, p. 442-464. In French.

Storms produce static charges in the skin of aircraft and can degrade the performance of VOR and HF radio equipment. The associated discharges take place at frequencies of 10 kHz to 350 MHz range, precisely the range of VOR and HF functioning. The charging is caused by the contact of dust, snow crystals and particles with the skin of the aircraft, the movement of electrons into aircraft engines and then along conducting pathways, and the formation of an inductive field around the aircraft. The associated voltage levels have intensities from 2-10 mA. Electrical models are defined for equipotential and nonequipotential aircraft and a helicopter. Tests are described with a static discharger-generator which emits a unipolar charge into the atmosphere in response to signals from a voltmeter registering the appearance of a given charge level around the aircraft. The application of antistatic coatings such as pulverized carbon to the aircraft or radome skin to enhance the resistivity of the surface is also discussed. M.S.K.

**A86-18696**

**INTERFERENCE WITH AERONAUTICAL AIDS TO NAVIGATION (FREQUENCIES OF 108-118 MHZ) BY HIGH POWER FM RADIO BROADCASTS (88-108 MHZ) [BROUILLAGE DES AIDES AERONAUTIQUES /FREQUENCES 108-118 MHZ/ PAR LA RADIODIFUSION SONORE A MODULATION DE FREQUENCE /88-108 MHZ/]**

J.-M. LOSCOS (Direction Generale de l'Aviation Civile, Service Technique de la Navigation Aerienne, Paris, France) Navigation (Paris) (ISSN 0028-1530), vol. 33, Oct. 1985, p. 465-474. In French.

The upper end of the frequencies used for commercial FM radio broadcasts meets the lower end of the frequencies employed by VOR and ILS beacons. The FM signals can interfere with aircraft navaids by directly overlapping with the navaid signals because of parasitic signals emitted by the broadcasting equipment, or by inducing interference signals within the on-board receivers. An intermodulation model has been defined for the conditions under which the spectra of FM signals will produce interference in on-board receivers. Tests of ILS and VOR receivers exposed to FM emissions verified the model and underscored the necessity of either inserting a passband filter at the entrance to the receivers or raising the threshold signal power for reception. It is noted that certain medical, citizens band and satellite television networks also produce signal spectra which can excite interference signals within aircraft navaids receivers. M.S.K.

**A86-18723**

**THE MICROWAVE LANDING SYSTEM (MLS) [DAS MIKROWELLEN-LANDESYSTEM /MLS/]**

G. WESTPHAL (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-Oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 5, 1985, p. 183-187. In German.

The ILS (Instrument Landing System), which has been used in civil aviation since 1953, has provided effective and very reliable aid to pilots in aircraft landing operations. However, steadily increasing demands with respect to the accuracy level of the control signals have now led to a situation in which a new landing system is needed to meet the requirements. After comprehensive tests involving various types of MLS, the ICAO has recommended the introduction of the Time Reference Scanning Beam (TRSB) system. The TRSB system is discussed, taking into account the basic concept of operation, the ground segment, a functional description, Precision Distance Measuring Equipment (PDME) of the TRSB, MLS onboard equipment, and the advantages and drawbacks of the MLS. Aspects concerning the introduction of the MLS in civil aviation are also considered. G.R.

**A86-18990**

**ANALYTICAL ESTIMATION OF THE VARIANCE OF ERROR IN DETERMINING GEOGRAPHIC-MERIDIAN DIRECTION BY THE GYROCOMPASS METHOD WITH RANDOM OSCILLATION OF THE BASE [ANALITICHESKAIA OTSENKA DISPERSII POGRESHNOSTI OPREDELENIIA NAPRAVLENIIA GEOGRAFICHESKOGO MERIDIANA METODOM GIROKOMPASIROVANIIA PRI SLUCHAINOM KOLEBANI OSNOVANIIA]**

IU. M. KHARLAMOV (Moskovskii Aviatsionnyi Institut, Moscow, USSR) Priborostroenie (ISSN 0021-3454), vol. 28, Nov. 1985, p. 88-91. In Russian.

**N86-14266#** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensgruppe Hubschrauber und Flugzeuge.

**AVIONICS SYSTEM FOR FUTURE CIVIL HELICOPTERS Final Report, Sep. 1984**

B. FORMICA Bonn Bundesministerium fuer Forschung und Technologie May 1985 168 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie

(BMFT-FB-W-85-005; MBB-UD-426/84; ISSN-0170-1339) Avail: NTIS HC A08/MF A01, Fachinformationszentrum, Karlsruhe, West Germany DM 33.50

Avionics and visual aids systems were tested to determine their applicability to civil helicopters. Economical uses, compatibility with the cockpit layout, the effects on the crew regarding work strain, and their reliability and mission capability were studied. Visual aids based on infrared imagery and light amplifying devices; central displays; autonomous navigation systems; obstacle warning radar; and central control and display units were considered. Author (ESA)

**N86-15278*#** Bolt, Beranek, and Newman, Inc., Cambridge, Mass.

**A FAULT TOLERANT SYSTEM FOR AN INTEGRATED AVIONICS SENSOR CONFIGURATION Final Report**

A. K. CAGLAYAN and R. E. LANCRAFT Sep. 1984 191 p refs

(Contract NAS1-16579)

(NASA-CR-3834; NAS 1.26:3834; BBN-5352) Avail: NTIS HC A09/MF A01 CSCL 01D

An aircraft sensor fault tolerant system methodology for the Transport Systems Research Vehicle in a Microwave Landing System (MLS) environment is described. The fault tolerant system provides reliable estimates in the presence of possible failures both in ground-based navigation aids, and in on-board flight control and inertial sensors. Sensor failures are identified by utilizing the analytic relationships between the various sensors arising from the aircraft point mass equations of motion. The estimation and failure detection performance of the software implementation (called FINDS) of the developed system was analyzed on a nonlinear digital simulation of the research aircraft. Simulation results showing the detection performance of FINDS, using a dual redundant sensor compliment, are presented for bias, hardover, null, ramp, increased noise and scale factor failures. In general, the results show that FINDS can distinguish between normal operating sensor errors and failures while providing an excellent detection speed for bias failures in the MLS, indicated airspeed, attitude and radar altimeter sensors. Author

# 05

# AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-16210**
**HELICOPTER PERFORMANCE**
D. M. LAYTON (U.S. Naval Postgraduate School, Monterey, CA) Beaverton, OR, Matrix Publishers, Inc., 1984, 218 p. refs

The elements of performance for rotary-wing aircraft are presented. The topics discussed include: blades, hinges, and controls; thust and torque theory; rotor flow effects; required power; antitorque and multiple rotors. Also considered are: autorotation; range and endurance; high-speed effects; performance testing; and computer programs. C.D.

**A86-16213**
**AIRCRAFT DESIGN**
R. RAUSA (U.S. Navy, Washington, DC), E. H. HEINEMANN, and K. VAN EVERY Baltimore, MD, Nautical and Aviation Publishing Company of America, Inc., 1985, 146 p.

A comprehensive introductory treatment is presented for the fundamental problems of aircraft design, as well as a number of the most noteworthy solutions given them by Heinemann. Emphasis throughout is given to the embodiment of sound design principles in Heinemann's A-4 'Skyhawk' naval attack aircraft, which although designed in the 1950s remains in active service with numerous air forces. Configuration design, structural design, propulsion system characteristics and integration, flight controls and aircraft stability, and landing gear and other subsystems, are each treated in turn. O.C.

**A86-17011**
**MODELLING FOR FATIGUE CRACK GROWTH PREDICTION IN AIRCRAFT**
J. M. FINNEY (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Fatigue and Fracture of Engineering Materials and Structures (ISSN 8756-758X), vol. 8, no. 3, 1985, p. 205-222. refs

Four fatigue crack growth (CG) models were examined for usefulness in predicting CG (in a fuselage frame of Mirage IIIO aircraft): the Wheeler (1972), the Willenborg (Willenborg et al., 1971), a modified Willenborg, and the Crack Closure (Bell and Creager, 1974; Bell and Wolfman, 1976) models. The CG rate analyses were compared with experimental data obtained on two regions of the aircraft frame. The Wheeler and the modified Willenborg retardation models were found to be the most satisfactory; however, both have shortcomings in that they require calibration by test and do not give accurate predictions (to better than a factor of 2 and, in some cases, of as much as 10) when specimen geometry and the test sequence are varied from those used in calibration tests. The main sources of inaccuracy are the inadequacy of the CG rate basic data, incorrect assumptions of crack shape, and uncertainty in stress history. Sample specifications and data graphs are included. I.S.

**A86-17061**
**ENGINE-OUT TAKE-OFF CLIMB - AN OLD AIRWORTHINESS PROBLEM REVIEWED**
R. NARASIMHA and M. R. ANANTHASAYANAM (Indian Institute of Science, Bangalore, India) ICAO Bulletin, vol. 40, Oct. 1985, p. 18-21.

A development history is presented for the technological and operational measures by which the engine-out (partial power) flight condition can be dealt with during the critical takeoff climb flight regime. Attention is given to the effects of aircraft fleet operational procedures on safety levels, and the progressive improvement of engine reliability over the 1950-1980 period. Control systems are recommended which increase the thrust of surviving engines substantially and manage aircraft maneuvers so that aircraft performance deviations from the norm (and pilot response) are no longer significant safety factors. O.C.

**A86-17068**
**METHODS FOR ROTOR AERODYNAMIC AND DYNAMIC ANALYSIS**
R. H. MILLER (MIT, Cambridge, MA) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 22, no. 2, 1985, p. 113-160. refs

The complex problems associated with the aerodynamics of blade/vortex interactions, the dynamics of a blade displaced out of its plane of rotation, and the position control of a hovering helicopter are discussed. Simplified models help to describe, and appear to be adequate for analyzing, many aspects of these problems. Free wake analyses are shown to be of importance in determining blade loads and performance for hovering flight or for wind turbines. Unsteady aerodynamics and careful definition of the wake formation are required when computing vibratory airloads in forward flight. Author

**A86-17070**
**MODAL CONSTRAINTS ON STRUCTURAL DYNAMIC FORCE DETERMINATION**
J. A. FABUNMI (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, Oct. 1985, p. 48-54. Army-supported research. refs

A numerical study was conducted to illustrate some factors which can affect the accuracy and effectiveness of helicopter dynamic force determination technology. These factors are related to the number and significance of the independent orthonormal modes participating in the helicopter response at the frequency of interest, compared to the number of independent forces being determined. The results show a strong correlation between the significance of the N(F)th mode and the error in the force determination procedure. It is concluded that the accuracy of dynamic force determination technology can be enhanced by insuring that the orthonormal modes which participate significantly in the response at a given frequency outnumber the independent forces that are being determined. C.D.

**A86-17381**
**28 YEARS OF FLIGHT TESTING HELICOPTERS**
J. BOULET Aerospace (UK) (ISSN 0305-0831), vol. 12, Nov. 1985, p. 17-22.

An autobiographical account is given of the helicopter flight testing experiences of Jean Boulet. Attention is given to the developmental testing of the Alouette I, II, and III helicopters in the 1950s, as well as to the effect of gradual technological refinement in the Super Frelon (1963), Puma (1965), Gazelle (1967), Lama (1969), Dauphin 360 (1972), Ecureuil (1974), and Dauphin 365C (1975). The consequences for helicopter safety of these technological developments are assessed. O.C.

**A86-17382**
**DESIGN AGAINST CORROSION**
G. B. EVANS (Workshop on Corrosion - In Service and Its Impact on Operations, Farnborough, England, Mar. 1985) Aerospace (UK) (ISSN 0305-0831), vol. 12, Nov. 1985, p. 23-28, 31-34.

The sources of material corrosion in aircraft structures are identified, and means by which they may be suppressed or precluded in the course of design development are evaluated. Attention is given to the environment in which the aircraft being contemplated will operate, the choice of materials for its critical structural elements, novel low corrosion metallic materials for airframe use, the influence of sharp edges, fuel tanks and mechanical fasteners, the electrical potential that can give rise to corrosion at mechanical joints employing several dissimilar metals, and external protection measures. O.C.

**A86-17435**
**TESTING TIME FOR AMX - THE CLOSE SUPPORT SPECIALIST MOVES TOWARDS PRODUCTION**
B. WANSTALL Interavia (ISSN 0020-5168), vol. 40, Nov. 1985, p. 1223-1225.

Four prototypes of the Italian/Brazilian 'AMX' attack aircraft are currently undergoing integrated flight testing in anticipation of an initial production run that will satisfy Italian and Brazilian Air Force orders of 187 and 79 aircraft, respectively. Although export marketing efforts are already underway, deliveries could not be made before 1989. Attention is presently given to the AMX's status as a weapons platform, as well as to the performance of the 5000-kg-thrust Spey Mk 807 turbofan engine. Two-seat and naval warfare versions of the AMX are under consideration. O.C.

**A86-17522**
**THE FIGHTER. II**
M. SPICK Air International (ISSN 0306-5634), vol. 29, July 1985, p. 24-31.

A development history is presented for interceptor fighter design from the end of the Korean War to the early 1960's, with attention to the course of debates among designers concerning the comparative advantages of cannon, unguided rocket, and guided missile weapons. Emphasis is given to the often highly innovative propulsion system design experiments conducted in the U.S., Britain and France during this period, which witnessed turbojet/ramjet and turbojet/rocket hybrid propulsion systems. Great stress was laid on high altitude, greater-than-Mach 2 speeds for the interception of supersonic, nuclear-armed strategic bombers. O.C.

**A86-17523**
**THE FIGHTER. III**
M. SPICK Air International (ISSN 0306-5634), vol. 29, Sept. 1985, p. 129-136.

A discussion is conducted on the comparative advantages projected by military aircraft designers since the 1960s for missile-armed and cannon-armed fighters, in light of such combat experiences as those afforded by the India-Pakistan wars of 1965 and 1971 and the Arab-Israeli wars of 1967, 1969-1970, and 1973. Attention is given to the ways in which the lessons thus learned were embodied in more recent fighter aircraft designs and armaments suites; tradeoffs are probed not only between missiles and cannon, but between shorter range IR-homing and longer range radar-homing missiles. O.C.

**A86-17525**
**2001 PHANTOM ODYSSEY**
M. SPICK Air International (ISSN 0306-5634), vol. 29, Dec. 1985, p. 287-292.

An evaluation is conducted of the modifications that have been made in the basic F-4 Phantom design since its introduction in U.S. Air Force and Navy service, in order to improve its overall performance and specialized mission capabilities. Attention is then given to experimental modification programs that have substantially altered some aspect of the basic configuration, such as canard control surfaces, as well as to prospective performance improvements that may accure to the use of lighter, more powerful state-of-the-art powerplants in place of the long-standard J-79 turbojets. Avionics and weapons suite reformulations are also under consideration, both in the U.S. and Israel. O.C.

**A86-17600**
**CHARACTERISTICS OF THE DESIGN OF VTOL JET AIRCRAFT [OSOBENNOSTI PROEKTIROVANIIA REAKTIVNYKH SAMOLETOV VERTIKAL'NOGO VZLETA I POSADKI]**
V. V. VOLODIN, N. K. LISEITSEV, and V. Z. MAKSIMOVICH Moscow, Izdatel'stvo Mashinostroenie, 1985, 224 p. In Russian. refs

The problems encountered at various stages of the design of VTOL jet aircraft are examined. In particular, attention is given to the calculation of forces and moments acting on VTOL aircraft during vertical takeoff and landing; modeling and analysis of aircraft control during vertical takeoff and landing; functional requirements for the control systems of VTOL aircraft and their design; and the design of the airframe and power plants of VTOL jet aircraft. The discussion also covers the calculations of the weight characteristics of VTOL aircraft, computer-aided design of general VTOL aircraft configurations, and an assessment of the efficiency of VTOL jet aircraft. V.L.

**A86-17698**
**RESPONSE OF A ROTORCRAFT MODEL WITH DAMPING NON-LINEARITIES**
B. H. TONGUE (Georgia Institute of Technology, Atlanta) Journal of Sound and Vibration (ISSN 0022-460X), vol. 103, Nov. 22, 1985, p. 211-224. refs

The linearized equations of motions of a helicopter in a contact with the ground have solutions which can be linearly stable or unstable, depending on the system parameters. The present study includes physical non-linearities in the helicopter model. This allows one to determine if a steady-state response exists and, if so, what the frequency and amplitude of the oscillations will be. In this way, one can determine how serious the linearly unstable operating regime is and whether destructive oscillations are possible when the system is in the linearly stable regime. The present analysis applies to helicopters having fully articulated rotors. Author

**A86-17779#**
**NONPLANAR, SUBSONIC, THREE-DIMENSIONAL OSCILLATORY PIECEWISE CONTINUOUS KERNEL FUNCTION METHOD**
I. LOTTATI and E. NISSIM (Technion - Israel Institute of Technology, Haifa, Israel) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1043-1048. refs

The rapid convergence characteristics and high accuracy of the three-dimensional piecewise continuous kernel function method are tested on a nonplanar configuration. The nature of the singularity of the three-dimensional kernel function for the nonplanar configuration is examined and anomalies associated with almost adjoining lifting surfaces are explained. Applications are made using the standard AGARD wing-tail configuration and the interference aerodynamic forces are compared with results obtained using other numerical methods. Author

**A86-17780*#** Massachusetts Inst. of Tech., Cambridge.
**SURFACE WETTING EFFECTS ON A LAMINAR FLOW AIRFOIL IN SIMULATED HEAVY RAIN**
R. J. HANSMAN, JR. (MIT, Cambridge, MA) and M. F. BARSOTTI Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1049-1053. Previously cited in issue 07, p. 853, Accession no. A85-19619. refs
(Contract NAG1-568)

**A86-17787#**
**HIGH-SPEED BRAKING OF AN AIRCRAFT TIRE ON GROOVED SURFACES**
S. K. AGRAWAL (FAA, Technical Center, Atlantic City, NJ) (ICAS, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 366-371) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1092-1096. Previously cited in issue 22, p. 3186, Accession no. A84-44969. refs

**A86-17790#**
**IMPACT OF LOADS RECORDING METHODOLOGY ON CRACK-GROWTH-BASED INDIVIDUAL AIRCRAFT TRACKING**
R. M. ENGLE, JR. (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and T. F. CHRISTIAN, JR. (USAF, Damage Tolerance Analysis Laboratory, Robins AFB, GA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1101, 1102. Previously cited in issue 03, p. 257, Accession no. A85-13516. refs

**A86-18401**

**NATIONAL SPECIALISTS' MEETING ON HELICOPTER TESTING TECHNOLOGY, WILLIAMSBURG, VA, OCTOBER 29-NOVEMBER 1, 1984, PROCEEDINGS**

Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1984, 319 p. For individual items see A86-18402 to A86-18429.

The present conference considers aeroelastic model helicopter rotor testing methods, developmental test techniques for composite helicopter airframes, drivestrain simulation requirements for helicopter clutch development, helicopter/ship dynamic interface flight testing, Kevlar filament-wound composite structure applications in helicopters, the certification of helicopter engine inlet ice protection systems, flight data analysis/storage systems, a pneumatic deicing system for helicopter rotors, and bench testing of helicopter drive systems. Also considered are wire strike protection systems, maintainability demonstration for U.S. Army helicopters, the NASA Langley 4 x 7-m rotorcraft wind tunnel, accelerated optimization and certification testing for helicopter deicing systems, integrated helicopter system testing, reliability and maintainability test data management for helicopter development, LHX helicopter simulation methods, avionics system integrated testing techniques, helicopter testing for the air-to-air combat role, and the testing of large helicopter transmissions. O.C.

**A86-18402*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AEROELASTIC MODEL HELICOPTER ROTOR TESTING IN THE LANGLEY TDT**

W. R. MANTAY, W. T. YEAGER, JR., M.-N. H. HAMOUDA, R. G. CRAMER, JR., and C. W. LANGSTON (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 18 p. Previously announced in STAR as N86-11523. refs

Wind-tunel testing of a properly scaled aeroelastic model helicopter rotor is considered a necessary phase in the design development of new or existing rotor systems. For this reason, extensive testing of aeroelastically scaled model rotors is done in the Transonic Dynamics Tunnel (TDT) located at the NASA Langley Research Center. A unique capability of this facility, which enables proper dynamic scaling, is the use of Freon as a test medium. A description of the TDT and a discussion of the benefits of using Freon as a test medium are presented. A description of the model test bed used, the Aeroelastic Rotor Experimental System (ARES), is also provided and examples of recent rotor tests are cited to illustrate the advantages and capabilities of aeroelastic model rotor testing in the TDT. The importance of proper dynamic scaling in identifying and solving rotorcraft aeroelastic problems, and the importance of aeroelastic testing of model rotor systems in the design of advanced rotor systems are demonstrated. Author

**A86-18403**

**DEVELOPMENTAL TESTING FOR COMPOSITE FRAMES**

J. LACY and E. DURCHLAUB (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Interlaminar shear stresses, and cap stresses that are due to curvature and to the use of bonded, rather than riveted connections between cap and web materials, are unique composite aircraft structural design concerns without precedents in metallic structural experience. A developmental testing program has accordingly been instituted as an essential element of the composite helicopter primary structure design process. Attention is presently given to the test sequence and to the results obtained for the case of all-composite ring frames of the Model 360 Advanced Techcnology Helicopter. Design confirmation has been achieved with simple test procedures, using coupons, frame section specimens, and entire airframes. O.C.

**A86-18404**

**DEVELOPMENT TESTING OF THE H-60 COMPOSITE MAIN ROTOR BLADE**

J. KIERAS and F. HERNANDEZ (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 20-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Attention is given to the efforts undertaken by a manufacturing methods and technology program for the development of an H-60 helicopter composite rotor blade, replacing current titanium-spar blades. Although the evaluation testing that must precede determination of a production blade configuration has not been completed, the prototype composite blade has demonstrated titanium blade-equivalent fatigue strength, as well as damage tolerance levels far above those of the metallic structure. Tests have also revealed that torsional stiffness and mass distribution should be tuned in the final blade configuration to match those of the titanium-spar blade. O.C.

**A86-18405**

**DYNAMIC INTERFACE - CONVENTIONAL FLIGHT TESTING PLUS A NEW ANALYTICAL APPROACH**

D. CARICO and S. L. MADEY, JR. (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 7 p. refs

Dynamic interface flight test programs have been instituted to achieve maximum operational capability and safety in helicopter shipboard landings; although much progress has been made, there remain many helicopter/ship-type combinations to be tested. Attention is presently given to a novel approach to the dynamic interface problem which emphasizes accelerated conventional testing in the near term and the development of an analytical capability for shipboard landings in the long term. This analytical capability calls for the development of shipboard landing data bases, as well as improvements in landing simulation. The goal is to be able to substitute a major portion of the conventional flight test effort with simulation and analysis techniques. O.C.

**A86-18408**

**FLIGHT TESTS OF THE HELICOPTER PNEUMATIC DEICING SYSTEM**

L. A. HAWORTH and M. S. GRAHAM (U.S. Army Aviation Engineering Flight Activity, Edwards AFB, CA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 9 p. refs

The flight tests conducted since 1980 to ascertain the capabilities of a prototype pneumatic deicing system for helicopter rotors, using a UH-1H helicopter test bed, have encompassed a structural loads survey, performance and handling qualities tests, rain erosion testing, and artificial and icing test performance evaluations. While the original prototype system led to significant aircraft performance degradation and minor effects on handling qualities, modifications to the prototype that were instituted in 1983 have yielded improved performance. Satisfactory deicing capabilities have been obtained in both artificial and natural icing conditions. O.C.

**A86-18411**

**HELICOPTER WIRE STRIKE PROTECTION SYSTEM QUALIFICATION TESTING**

L. T. BURROWS (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 10 p.

The Wire Strike Protection System (WSPS) whose qualification testing has recently been conducted consists of deflectors and cutters, and furnishes helicopters with significant protection from damage due to taut wire strikes in low level flight. The full scale

WSPS testing technique was formulated to assess the system's capabilities and limitations, structural integrity, and potential effects on the helicopter airframe during the wire impact/deflection/cutting sequence. This qualification test regime has been applied to OH-58A, UH-1H, AH-1S, OH-6A, and UH-60A military helicopters equipped with WSPS. O.C.

**A86-18416**

### NEW TECHNIQUES FOR OPTIMIZATION AND CERTIFICATION OF HELICOPTERS IN ICING CONDITIONS

P. J. DUNFORD (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 30 p.

An accelerated two-year development/certification test program was undertaken to furnish the RAF's Chinook helicopters with all-weather operational capability; this involved the incorporation of a heated rotor blade deicing system. Attention is given to the development of a system combining flexible deicing control with real time data analysis techniques for on-board decision-making. Increased test flight productivity and accelerated development were obtained by this means. Detailed postflight analyses by a ground station were, however, essential to overall success. O.C.

**A86-18418**

### OPERATIONAL TESTING EXPERIENCE ON THE AH-64A APACHE

R. D. WATSON (McDonnell Douglas Corp., Hughes Helicopters, Inc., Culver City, CA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 10 p.

A process of laboratory integration, vehicle ground integration testing, and flight evaluation, in which design changes were 'iteratively' incorporated after a given testing stage, was conducted for the Apache military helicopter's weapon system. Software development was expedited during the test phase to furnish fast, yet controlled turn-around of software updates. The system provided complete updates as well as field patches, and an identification system that provided configuration control and correlation with flight test results. Integration emphasis was placed on the MIL-STD-1533A multiplex bus system. O.C.

**A86-18419**

### R&M TEST DATA MANAGEMENT DURING HELICOPTER SYSTEM DEVELOPMENT

K. H. EAGLE and G. WINDOLPH (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 6 p.

The primary objective of helicopter testing from the reliability and maintainability (R&M) viewpoint is the identification of as-yet unknown failure modes and the quantification of failure rates for known ones. Attention is presently given to the case of the CH-46 helicopter's R&M program, whose test data collection and data analysis program involved the logging and tracking of each failure event. On the basis of the occurrence frequency and criticality of a given event, responses ranging from continued monitoring during testing to full design change corrective action are formulated. Documentation is furnished for each such decision. O.C.

**A86-18420**

### RELIABILITY DEVELOPMENT TESTING OF SH-60B HELICOPTER MECHANICAL SYSTEMS

R. L. HOLT and G. A. NEYSSEN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 15 p.

Testing techniques aimed toward the development of reliability of helicopter mechanical components are illustrated for the case of the SH-60B's systems for Recovery Assist, Securing and Traversing, rotor bladefolding, rotor brake, and sonobuoy launching. These tests were designed to simulate 5000 hours of repeated aircraft operational cycles, in critical environmental conditions which encompassed sand and dust, salt spray, high temperature and humidity, icing, and vibration. System components, relative component locations, and connecting hardware were duplicated for evaluation of possible interaction effects. O.C.

**A86-18421**

### THE ROLE OF SIMULATION FOR THE LHX

T. R. METZLER (U.S. Army, Aviation Systems Command, St. Louis, MO) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 7 p.

The use of full existing capabilities for simulation of the range of combat helicopter operational conditions and behavior, from aerodynamics to tactical performance, are expected to yield significant advantages in the design of major 'LHX' helicopter elements. Simulation has been rendered critical by a compressed and accelerated development program, crew size reductions, and complex integrations of advanced technologies. The state-of-the-art simulation technology in question is software-intensive, and is therefore substantially more independent of electromechanical systems than past simulation technologies. O.C.

**A86-18422**

### SIMULATING THE TOTAL SYSTEM, WARTS AND ALL

P. B. BRIGHAM (Martin Marietta Corp., Orlando, FL) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Extensive use will be made of simulation to validate automation concepts during the development of the U.S. Army's next-generation 'LHX' helicopter. In the scout/attack role, the LHX will be operated by a single crewman and must therefore rely on an unprecedented degree of onboard-systems automation. Attention is presently given to the method that will be used to model automatic sensor recognition and sensor fusion functions with a degree of fidelity that can realistically support evaluations of the effects of false alarms, incorrect target classifications, and missed targets (in the presence of targets and target-like clutter elements) in man-in-the-loop mission simulations. O.C.

**A86-18424**

### TESTING HELICOPTERS FOR THE AIR-TO-AIR COMBAT ROLE

J. J. MCCUE, L. E. SCOTT, and J. G. CASLER (U.S. Navy, Naval Test Pilot School, Patuxent River, MD) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 32 p. refs

Attention is given to a methodology suitable for the simulation of helicopter-vs.-helicopter air-to-air combat, taking into account the adoption of evasive maneuvering as an essential element of mission capabilities for combat helicopters of the LHX/PAM-2/A-129 class. The highly agile, rigid rotor BK 117 and Hughes 530 helicopters are the subjects of planned air combat tests, which will generate a data base that can be used by helicopter designers, weapons specialists, and helicopter tacticians as the basis of evasive maneuvering capability improvements in future systems. O.C.

**A86-18427**

**U.S. ARMY/SIKORSKY ACAP AIRFRAME TEST TECHNIQUES/METHODOLOGY**

H. L. KEARNEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and D. GOOD (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 14 p.

Special considerations and test techniques used during static testing of the U.S. Army/Sikorsky Advanced Composite Airframe Program (ACAP) airframe are discussed. Included are considerations for accountability for effects of prolonged environmental exposure on composite material strength, and establishment of limit and ultimate load criteria. Techniques used for damage detection and inspection, and the problems and solutions associated with repairing bonded composite structures damaged during test conduct are described. Author

**A86-18428*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**VERIFICATION OF STATIC ROTOR-LOAD MEASUREMENT CAPABILITIES OF THE RSRA HELICOPTER ACTIVE-ISOLATOR SYSTEM**

C. W. ACREE, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 15 p.

The Rotor Systems Research Aircraft helicopter technology demonstration test bed incorporates an active isolator system which reduces the rotor vibrations that are transmitted to the airframe and allows the simultaneous measurement of all six forces and moments generated by the rotor. The first full system calibration was performed in 1983 to verify the system's static load measurement capabilities; the analysis of the data encompassed multiple linear regressions to determine calibration matrices for different data sets, and a hysteresis removal algorithm for the estimation of in-flight measurement errors. The results obtained indicate that the active isolator system meets most performance predictions. O.C.

**A86-18443**

**THE AV-8B FATIGUE TEST PROGRAM**

N. D. NEWMAN (McDonnell Aircraft Co., St. Louis, MO) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 14-0 to 14-27.

A structural fatigue test program was conducted over 1982-1984 as part of the AV-8B Full Scale Development Program which encompassed a full scale airframe fatigue test and auxiliary fatigue tests of both metallic and composite structural components. The 12,000 hours of severe airframe use thus simulated were equivalent to two service lifetimes. Attention is given to the AV-8B's fatigue design philosophy, load spectra, fatigue test methods, and test results, with attention to problem resolution. O.C.

**A86-18444**

**SH-2F AIRFRAME FATIGUE TEST PLAN**

W. F. ALEX (Kaman Aerospace Corp., Bloomfield, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 15-1 to 15-15.

Since the U.S. Navy intends to operate the SH-2F helicopter in service past the year 2000, they have presented a contract to Kaman Aerospace Corporation requesting a plan for a fatigue test of a full-scale SH-2F fuselage with the objective of substantiating a 20,000 hour service life for the airframe. Kaman is presently in the preliminary stage of organizing this plan. This paper summarizes the results of past fatigue tests involved with the H-2 fuselage. It also described the basic of the load-time spectrum to be employed in the new test, the form and types of test loads to be applied to simulate flight loads excursions, and the methods to be used to apply and control the test loads. In addition, it discusses the manner in which the test will be conducted in order that the results may be logically interpreted to determine the inspection intervals and possible periodic modifications, or repairs, that may be necessary to achieve the required service life. Author

**A86-18445**

**HELICOPTER FATIGUE - THE CHANGING SCENE**

J. W. BRISTOW (Civil Aviation Authority, Airworthiness Div., Redhill, England) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 17-1 to 17-16.

The British Civil Aviation Authority Airworthiness Division became increasingly aware, over the 1980-1984 period, that the safety record of fatigue-related helicopter failures could be enhanced. Attention is presently given to steps being taken with this end in mind, which encompass the reassessment of manufacturers' fatigue substantiation testing methods, the monitoring of the effects of corrosion, deterioration and wear by both operators and manufacturers, and the specification of the validity of any declared service life in terms of flight profile or spectrum. In the absence of fail safe/damage tolerance features, the requirements should provide for substantially higher strength reduction factors. O.C.

**A86-18446**

**DAMAGE TOLERANCE ANALYSIS OF COMPONENTS OF ROTOR WING AIRCRAFT**

R. BOORIA (Bell Helicopter Textron, Fort Worth, TX) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 18-1 to 18-31. refs

The feasibility of applying the specifications of MIL-STD-1530A to dynamic components of tilt rotor aircraft was investigated by analyzing a representative sample of components from three significant functional areas of the XV-15 aircraft. The yoke from the hub assembly, the rotating ring from the controls system and the mast from the drive system were the three components chosen. These components reflect diversity in material (excluding composites) as well as different combinations of mean and oscillatory load levels. The weight penalty estimates were made by comparing the weight of the damage tolerant configuration with that of a 10,000 hour safe-life configuration. The initial flaw sizes were 0.015 x 0.030 for surface flaws and 0.015 x 0.015 for cracks emanating from holes and corners. Of the three components analyzed, only the yoke has incurred a weight penalty. The rotating ring and mast were shown to be damage tolerant in their current design configurations. Author

**A86-18447**

**THE APPLICATION OF FATIGUE DAMAGE TOLERANCE CONCEPTS TO HELICOPTERS - THE APPROACH PROPOSED BY THE UK MILITARY AIRWORTHINESS AUTHORITIES**

A. CARDRICK, R. MAXWELL, and S. MORROW (Royal Aircraft Establishment, Airworthiness Div., Farnboroush, England) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 19-1 to 19-38. refs

The principles governing fatigue damage tolerance that have been proposed by the British military airworthiness authorities for helicopters give attention to tolerance to unforseen high stresses, and reduce sensitivity to defects arising during both manufacturing and service. A comparison is presently conducted between the implications of sizing principal structural feature types to this novel approach, and to an alternative strategy (introduced by the USAF and currently under consideration by the FAA) which is based on abnormal defects. Calculations employing the safe life approach furnish a benchmark for this comparison; it is shown that the choice of strategy can have a substantial influence on allowable stresses. O.C.

**A86-18448**

### DAMAGE TOLERANCE AND CIVIL HELICOPTER DESIGN

R. T. WEAVER (FAA, Fort Worth, TX) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 20-1 to 20-22. refs

As damage tolerance design approaches and substantiation methods gain in application and practicality, efforts to apply these approaches to civil helicopter design are being made. Helicopters, because of their load environment, would profit even more than airplanes from damage tolerance design features but because of their mechanical and structural complexity, helicopters are more difficult to be made damage tolerant. Accordingly, the FAA has generated a program to add damage tolerance to the civil transport helicopter regulations. The FAA program to add damage tolerance requirements to the civil helicopter regulations is designed to encourage the use of mature damage tolerance technology and the development of additional design features and methodologies. The application of multiple load path features as well as fracture mechanics methodologies is encouraged to achieve the goals of this program which are to save lives and otherwise increase safety. Author

**A86-18449**

### DAMAGE TOLERANCE ANALYSIS OF THE H-53 HELICOPTER

J. W. LEWIS, JR. (USAF, Warner Robins Air Logistics Center, Robins AFB, GA), G. J. SCHNEIDER, and J. L. PRATT (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 21-1 to 21-21.

Sikorsky Aircraft is currently conducting a damage tolerance assessment (DTA) of the H-53 helicopter. This task provides an opportunity to evaluate the concept, requirements and analytical techniques of damage tolerance analysis as applied to rotary wing aircraft. The DTA effort is a three-phase program consisting of: (1) identification and screening of critical locations, (2) development of an interactive computer program (runstream) for crack growth analysis, and (3) crack growth analysis and determination of force management actions. Sikorsky is now approaching the end of the second phase. This paper is an overview of the accomplished and planned work as well as problems encountered. Author

**A86-18457**

### TOMORROW'S COCKPIT TECHNOLOGY IN TODAY'S MODERN HELICOPTER

W. P. REA (Hughes Helicopters, Inc., Culver City, CA) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

The new 530 MG Defender is a light weight, multirole combat helicopter which makes maximum use of the integrated cockpit concept. Compact, swift and agile, the 530 MG Defender is engineered to provide broad mission flexibility through the use of a modular, quick change weapon system and a control avionics management system with a flexible interface. The cockpit is designed to centralize primary flight information displays and controls for maximum crew visibility in day and night nap-of-the-earth flight. The heart of the cockpit is the Integrated Control and Display System which utilizes a mission computer, multifunction display, control display unit, symbol generator, and a mission data transfer devcie. All are linked by a MIL-STD-1553 multiplex data bus, which easily accommodates system growth on a plug-in basis. The copilot has a stowable Virtual Image Display (VID) to view the TOW antitank missile's mast-mounted sight video for either reconnaissance, target tracking or TOW guidance. The VID can also be used for nighttime reconnaissance in conjunction with the nose-mounted forward-looking IR system. Author

**A86-18733**

### AEROELASTICITY AND DYNAMICS OF THE HELICOPTER STRUCTURE [AEROUPRUGOST' I DINAMIKA KONSTRUKTSII VERTOLETA]

O. P. BAKHOV Moscow, Izdatel'stvo Mashinostroenie, 1985, 176 p. In Russian. refs

Methods for calculating and selecting helicopter parameters with allowance for the dynamics of the helicopter structure are presented. In particular, attention is given to the analysis of the self-oscillations of rotors mounted on an elastic structure, selection of stiffness and weight characteristics, and methods for the design optimization of the structures of heavy twin-rotor helicopters of transverse arrangement and tail rotors. Methods of experimental studies of helicopters and dynamically similar models are also examined. V.L.

**A86-18740**

### THE OXYGEN EQUIPMENT OF PASSENGER AIRCRAFT [KISLORODNOE OBORUDOVANIE PASSAZHIRSKIKH SAMOLETOV]

E. M. PESHKOV, V. B. CHERTOK, and V. L. CHUGUNOV Moscow, Izdatel'stvo Transport, 1985, 144 p. In Russian. refs

The effect of various factors on the human body under conditions of reduced pressure is reviewed, and the life support systems of passenger aircraft are briefly characterized. In particular, attention is given to the design and principles of operation of oxygen-supply systems for the crew and the passengers. The discussion covers stationary and portable oxygen systems, the efficiency of passenger oxygen systems, and guidelines for using oxygen equipment. Finally, the maintenance of oxygen systems and their evaluation and inspection are discussed. V.L.

**A86-19277**

### INFLUENCE OF ROUGH RUNWAYS ON UNDERCARRIAGE DESIGN

G. H. HAINES (Dowty Rotol, Ltd., Gloucester, England) Aircraft Engineering (ISSN 0002-2667), vol. 57. Nov. 1985, p. 2-8.

An examination is presented of those aspects of aircraft landing gear design that are pertinent to rough ground operation capability, in view of such quantifiable factors as discrete roughness of ground, deterministic runway profiles, and statistically defined runway profiles. Attention is given to the consequences of shock absorber and tire characteristics, and to the effect of higher shock absorber reaction levels on undercarriage design. The inherent limitations to what can be achieved through shock absorber damping and spring curve changes are noted. O.C.

**A86-19290**

### AIRCRAFT RELIABILITY, SAFETY, AND LIFETIME [NADEZHNOST', BEZOPASNOST' I ZHIVUCHEST' SAMOLETA]

L. L. ANTSELIOVICH Moscow, Izdatel'stvo Mashinostroenie, 1985, 296 p. In Russian. refs

The principal design factors affecting the reliability and lifetime of aircraft are considered. Theoretical reliability issues in the design of military and commercial aircraft are discussed, with emphasis given to: the concept of failure as a random event; the distribution of discrete random values for the probability of failure; and the properties of reliability indices. Numerical techniques for predicting times to failure in various types of aircraft are described. Some practical techniques for enhancing aircraft lifetime are also discussed, including: periodic reliability testing of aircraft parts; preflight and post-flight inspections; and basic aircraft repairs. I.H.

**N86-14267*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**DETERMINATION OF CORRECTIONS TO FLOW DIRECTION SENSOR MEASUREMENTS OVER AN ANGLE-OF-ATTACK RANGE FROM 0 DEGREE TO 85 DEGREES M.S. Thesis - George Washington Univ., August 1983**
T. M. MOUL Dec. 1985 52 p refs
(NASA-TM-86402; L-15759; NAS 1.15:86402) Avail: NTIS HC A04/MF A01 CSCL 01C

An investigation was conducted into the nature of corrections for angle-of-attack and angle-of-sideslip measurements obtained with sensors mounted in front of each wingtip of a general aviation airplane. These flow corrections have been obtained from both wind-tunnel and flight tests over an angle-of-attack range from 0 to 85 deg. Both the angle-of-attack and angle-of-sideslip flow corrections were found to be substantial. The corrections were a function of the angle of attack and angle of sideslip and were fairly insensitive to configuration changes and rotational effects. The angle-of-attack flow correction determined from the static wind-tunnel tests agreed reasonably well with the correction determined from flight tests. Author

**N86-14268#** Naval Postgraduate School, Monterey, Calif.
**COMPUTER PROGRAM FOR PERFORMANCE PREDICTION OF TANDEM-ROTOR HELICOPTERS M.S. Thesis**
D. L. COTNER Jun. 1985 42 p
(AD-A159193) Avail: NTIS HC A03/MF A01 CSCL 01C

A computer program for the HP-41 series calculator is presented which predicts the rotor shaft horsepower required for tandem-rotor helicopters to a given set of helicopter parameters and flight conditions. Three simplified analytical methods of calculating the induced power for tandem-rotor helicopters were explored during the development of the program and their effect on the total shaft horsepower required was compared to actual test data. These comparisons as well as size and complexity considerations were used in selecting the method to be used. The program can be used in preliminary design analysis and as an educational tool where only an estimate of the actual shaft horsepower is required. Author (GRA)

**N86-14269#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Hauptabt. Verkehrsforschung.
**INVESTIGATIONS OF THE AIRCRAFT LANDING PROCESS USING A COMPUTERIZED SIMULATION MODEL BASED ON THE MONTE CARLO METHOD**
H. J. PETERS May 1985 111 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-951)
(DFVLR-FB-85-27; ISSN-0171-1342) Avail: NTIS HC A06/MF A01; DFVLR, Cologne DM 35.50

A landing approach simulation model based on the data from a civil airport and on the Monte Carlo theory is developed using the General Purpose Simulation System on FORTRAN 4. The model is improved to investigate the landing process with constant and variable landing times. The theoretical landing time distribution with waiting times verified with the Chi-square test show good agreement with the empirical landing time distribution. The turn time and landing time distribution with waiting time parameters are verified by statistical comparison of the simulated distribution and the empirical one. The efficiency of the test distributions is improved with a relevant landing time delimitation. The test distributions are tested successfully in other airports. Author (ESA)

**N86-15279#** Aeronautical Research Labs., Melbourne (Australia).
**AN OPTIMISATION METHOD FOR RECONSTRUCTION OF FLIGHT PATH TRAJECTORIES FROM NON-SYNCHRONOUS TIME-SAMPLED OBSERVATIONS BY TWO CINE CAMERAS**
A. ROSS, L. MOCKRIDGE, and D. DRUMM Oct. 1984 68 p refs
(ARL-SYS-R-34; AR-003-969) Avail: NTIS HC A04/MF A01

Helicopter flight path trajectories in approach to a tactical landing aid were monitored, ad hoc, by two cine cameras. Post-trial trajectory reconstruction using simple triangulation methods was confounded by the presence of an unknown bias error in the orientation of one camera, and by nonsynchronous camera timing. The report describes the concept, formulation and implementation of an optimization method which pools all data for a trajectory, permits extraction of bias terms, and yields a complete trajectory smoothed in space and time. Author

**N86-15280*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**ROTORCRAFT DYNAMICS 1984**
Nov. 1985 497 p refs Proceedings of the 2d Decennial Specialists' Meeting on Rotorcraft Dynamics, Moffett Field, Calif., 7-9 Nov. 1984; sponsored by NASA. Ames Research Center and the American Helicopter Society
(NASA-CP-2400; REPT-85122; NAS 1.55:2400) Avail: NTIS HC A21/MF A01 CSCL 01C

In the conference proceedings are 24 presented papers, their discussions, and material given in two panels. The presented papers address the general areas of the dynamics of rotorcraft or helicopters. Specific topics include the stability of rotors in hover and forward flight, the stability of coupled rotor-fuselage systems in hover, the loads on a rotor in forward flight including new developments in rotor loads calculations, and the calculation of rotorcraft vibration and means for its control or suppression. Material in the first panel deals with the successful application of dynamics technology to engineering development of flight vehicles. Material in the second panel is concerned with large data bases in the area of rotorocraft dynamics and how they are developed, managed, and used.

**N86-15285*#** Sikorsky Aircraft, Stratford, Conn.
**TEST RESULTS FROM A DYNAMIC MODEL DYNAFLEX ROTOR**
C. F. NIEBANCK and R. K. GOODMAN *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 57-68 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

A one-fifth scale dynamic model of the Sikorsky Dynaflex rotor was tested in hover and in forward flight conditions in a wind tunnel. The Dynaflex rotor features an advanced composite structure which flexes to provide a constant speed universal joint action. Testing concentrated on confirming that the stability and dynamic response of the rotor were satisfactory. Lift conditions of up to .11 Ct/sigma and advance ratios as high as .46 were reached. Vibratory loads were compared to those of articulated rotors. The Dynaflex rotor concept appears to be a practical concept from the standpoint of dynamic response and stability. Author

**N86-15290*#** Kaman Aerospace Corp., Bloomfield, Conn.
**OPTIMAL DESIGN APPLICATION ON THE ADVANCED AEROELASTIC ROTOR BLADE**
F. S. WEI and R. JONES *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 137-151 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

The vibration and performance optimization procedure using regression analysis was successfully applied to an advanced aeroelastic blade design study. The major advantage of this regression technique is that multiple optimizations can be performed to evaluate the effects of various objective functions and constraint functions. The data bases obtained from the rotorcraft flight simulation program C81 and Myklestad mode shape program are analytically determined as a function of each design variable. This approach has been verified for various blade radial ballast weight locations and blade planforms. This method can also be utilized to ascertain the effect of a particular cost function which is composed of several objective functions with different weighting factors for various mission requirements without any additional effort. Author

**N86-15291*#** Sikorsky Aircraft, Stratford, Conn. Dynamics Methods.
**DEVELOPMENT AND APPLICATION OF A TIME-HISTORY ANALYSIS FOR ROTORCRAFT DYNAMICS BASED ON A COMPONENT APPROACH**
R. SOPHER and D. W. HALLOCK *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 153-169 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

A time history analysis for rotorcraft dynamics based on dynamical substructures, and nonstructural mathematical and aerodynamic components is described. The analysis is applied to predict helicopter ground resonance and response to rotor damage. Other applications illustrate the stability and steady vibratory response of stopped and gimballed rotors, representative of new technology. Desirable attributes expected from modern codes are realized, although the analysis does not employ a complete set of techniques identified for advanced software. The analysis is able to handle a comprehensive set of steady state and stability problems with a small library of components. Author

**N86-15292*#** Boeing Vertol Co., Philadelphia, Pa.
**RESTRUCTURING THE ROTOR ANALYSIS PROGRAM C-60**
*In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 171-185 Nov. 1985
Avail: NTIS HC A21/MF A01 CSCL 01C

The continuing evolution of the rotary wing industry demands increasing analytical capabilities. To keep up with this demand, software must be structured to accommodate change. The approach discussed for meeting this demand is to restructure an existing analysis. The motivational factors, basic principles, application techniques, and practical lessons from experience with this restructuring effort are reviewed. Author

**N86-15304*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**EVALUATION OF A LOAD CELL MODEL FOR DYNAMIC CALIBRATION OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT**
R. W. DUVAL (Advanced Rotorcraft Technology, Inc., Los Altos, Calif.), H. BAHRAMI, and B. WELLMAN *In its* Rotorcraft Dynamics 1984 p 379-393 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

The Rotor Systems Research Aircraft uses load cells to isolate the rotor/transmission system from the fuselage. An analytical model of the relationship between applied rotor loads and the resulting load cell measurements is derived by applying a force-and-moment balance to the isolated rotor/transmission system. The model is then used to estimate the applied loads from measured load cell data, as obtained from a ground-based shake test. Using nominal design values for the parameters, the estimation errors, for the case of lateral forcing, were shown to be on the order of the sensor measurement noise in all but the roll axis. An unmodeled external load appears to be the source of the error in this axis. Author

**N86-15305*#** Boeing Commercial Airplane Co., Seattle, Wash.
**F-111 NATURAL LAMINAR FLOW GLOVE FLIGHT TEST DATA ANALYSIS AND BOUNDARY LAYER STABILITY ANALYSIS Contractor Report, Aug. 1981 - Jul. 1983**
L. J. RUNYAN, B. H. NAVRAN, and R. A. ROZENDAAL Jan. 1984 224 p refs
(Contract NAS1-15325)
(NASA-CR-166051; NAS 1.26:166051; D6-51153) Avail: NTIS HC A10/MF A01 CSCL 01C

An analysis of 34 selected flight test data cases from a NASA flight program incorporating a natural laminar flow airfoil into partial wing gloves on the F-111 TACT airplane is given. This analysis determined the measured location of transition from laminar to turbulent flow. The report also contains the results of a boundary layer stability analysis of 25 of the selected cases in which the crossflow (C-F) and Tollmien-Schlichting (T-S) disturbance amplification factors are correlated with the measured transition location. The chord Reynolds numbers for these cases ranges from about 23 million to 29 million, the Mach numbers ranged from 0.80 to 0.85, and the glove leading-edge sweep angles ranged from 9 deg to 25 deg. Results indicate that the maximum extent of laminar flow varies from 56% chord to 9-deg sweep on the upper surface, and from 51% chord at 16-deg sweep to 6% chord at 25-deg sweep on the lower. The results of the boundary layer stability analysis indicate that when both C-F and T-S disturbances are amplified, an interaction takes place which reduces the maximum amplification factor of either type of disturbance that can be tolerated without causing transition. Author

**N86-15306#** Army Training and Doctrine Command, Fort Monroe, Va.
**LIGHT HELICOPTER FAMILY TRADE-OFF ANALYSIS. VOLUME 4: APPENDIX N Final Report**
R. FICO, J. WALLACE, B. SIMPSON, and N. H. CLEEK 15 May 1985 452 p
(AD-A158075; AD-F630692) Avail: NTIS HC A20/MF A01 CSCL 01C

During the Light Helicopter Family (LHX) Trade-Off Analysis (TOA), 10 major areas of aircraft performance and subsystems were evaluated. These 10 substudies formed the following Annexes: (1) light helicopter family (LHX) subsystems; (2) structures- pertinent issues and systems characteristics; (3) LHX deployability; (4) vertical flight analysis; (5) maneuverability/agility analysis; (6) level flight analysis speed; (7) level flight analysis - cruise efficiency; (8) level flight analysis - one engine inoperative (OEI); (9) multiple attribute decision making analysis; and (10) aircraft performance and engine power margin. These substudies with a summary formed this volume of the LHX TOA Report. GRA

**N86-15307#** Army Training and Doctrine Command, Fort Monroe, Va.
**LIGHT HELICOPTER FAMILY TRADE-OFF ANALYSIS. VOLUME 7: APPENDIX R Final Report**
P. W. HICKMAN, R. N. ARMSTRONG, and N. H. CLEEK 15 May 1985 613 p
(AD-A158076; AD-F630692) Avail: NTIS HC A99/MF A01 CSCL 01C

Thirteen subanalyses were performed and reported in Annexes found within this HF/MMI volume. Their titles follow and are fairly descriptive of both the substudy's emphasis and contents: (1) projective application of the subjective workload assessment technique to advance helicopter crew system designs; (2) human factors engineering review of the integrated crewstation for the LHX; (3) tactical implications of one-man versus two-man aircrews for the LHX; (4) a computer analysis to predict crew workload during LHX scout-attack missions; (5) visually coupled airborne systems simulator (VCASS) LHX cockpit simulation; (6) human factors assessment of voice technology of the LHX cockpit simulation; (7) issues for a trade-off analysis of conventional; versus advanced cockpit controllers for the LHX; (8) biomedical analysis of visual displays and cockpit design options for the LHX; (9) NBC contamination protection, detection, and decontamination concepts analysis for the LHX; (10) humman factors engineering assessment of navigation systems for the LHX; (11) the integration of voice and visual displays for aviation systems; (12) theory and measurement of human workload; and (13) pilot workload, performance, and aircraft control automation. GRA

**N86-15308#** Army Training and Doctrine Command, Fort Monroe, Va.

**LIGHT HELICOPTER FAMILY TRADE-OFF ANALYSIS. VOLUME 8: APPENDICES S AND T Final Report**

E. M. BERTA, F. C. SAUTTER, M. SYKES, N. H. CLEEK, and R. FLYNN 15 May 1985 167 p
(AD-A158077; AD-F630692) Avail: NTIS HC A08/MF A01
CSCL 01C

This volume of the light helicopter family (LHX) trade-off analysis (TOA) report contains the reports of two seperate but related analyses. The first is the force structure analysis that identifies the foreseeable impact of the LHX on the Army's aircraft and manpower requirements. The study concludes that: (1) the total LHX force structure requirements are: (a) LHX-SCAT - 3,072 aircraft; and (b) LHX-Utility - 1,951 aircraft; and (2) depending on LHX candidate, maintenance personnel savings of 8 to 10% are achievable. The second analysis is of reliability, availability, and maintainability/logistics (RAM/LOG). The RAM/LOG analysis intended to identify and quantify the minimum values of RAM and associated supportability goals that the LHX would need to achieve. The RAM/LOG findings/conclusions included: (1) optimum unit size: (a) 11 aircraft per attack helicopter battalion company; and (b) 10 aircraft per aviation reconnaissance squadron troop; (2) 5.7 to 5.8 aircraft flying hours per aircraft per day are the objective flight program; (3) 1.0-hour mean time to repair; (4) 3.6-maintenance man-hours/flight hour maintenance ratio; and (5) 7.1 to 8.7 hours mean time between mission about failure (minimum acceptable value). GRA

**N86-15309#** Army Training and Doctrine Command, Fort Monroe, Va.

**LIGHT HELICOPTER FAMILY TRADE-OFF ANALYSIS. VOLUME 10: APPENDICES V, W, X, AND Z Final Report**

B. ROBERTS, J. PARRISH, B. J. WATTS, N. H. CLEEK, and P. HICKMAN 15 May 1985 194 p
(AD-A158079; AD-F630692) Avail: NTIS HC A09/MF A01
CSCL 01C

This volume of the light helicopter family (LHX) trade-off analysis (TOA) report gives the details of four substudies done within the TOA. These substudy areas were: safety, cost, commonality, and downwash. The findings/conclusions reached by the Safety Analysis included: (1) the LHX should be planned for two crewmembers; (2) the LHX should be designed with two engines; (3) these important safety design features should be included in the LHX: (a) twin engines with an OEI flight capability; (b) effective antitorque control under all mission flight environments; (c) no tail rotor or a high degree of protection for the tail rotor; (d) visionics system for use during reduced visibility conditions; (e) wire strike protection system (WSPS); (f) backup or redundant flight control system; (g) wheeled landing gear; (h) rigid or redundant flight control system; (i) maintenance and flight data recorders; (j) performance planning computer; and (k) automated systems to reduce pilot workload; and (4) the following crashworthiness items are important and should be features of the LHX: (a) crashworthy fuel systems; (b) high mass item retention; (c) high-energy absorption gear (fixed or automatic extension) and fuselage; (d) crew seat and restraint system; (e) troop seat and restraint system; (f) noninjurious cockpit environment; and (g) emergency locator transmitter (ELT). GRA

**N86-15310#** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.

**AIRCRAFT FLIGHT PERFORMANCE METHODS. REVISION 2 Final Report, Jun. 1974 - Jul. 1975**

L. E. MILLER and P. G. KOCH Jul. 1985 284 p
(Contract DA PROJ. 136-6)
(AD-A158227; AFFDL-TR-75-89-REV-2) Avail: NTIS HC A13/MF A01 CSCL 01B

This report addresses the problems associated with the derivation of aircraft performance characteristics. The emphasis is on segments which are a part of a mission profile. In particular, the following areas are studied; takeoff, climb, cruise, descent and glide, turning, and landing. The generalized approach to performance estimates is first presented. Next, appropriate solutions are derived. Last sensitivity relationships are developed. The relationships determine changes in the performance characteristics as a result of an aircraft configuration change. This permits rapid evaluation of the performance variations for any segment of a mission profile. GRA

**N86-15311#** Center for Naval Analyses, Alexandria, Va. Naval Planning Manpower and Logistics Div.

**THE RELATIONSHIP BETWEEN MATERIAL FAILURES AND FLIGHT HOURS: STATISTICAL CONSIDERATIONS**

M. S. GOLDBERG Jan. 1985 22 p
(Contract N00014-83-C-0725)
(AD-A159571; CNA-PP-430) Avail: NTIS HC A02/MF A01
CSCL 01C

This paper attempts to clarify the relationships among the following four hypotheses: (1) the number of material failures across intervals of calender time containing equal accumulated flight hours follows a Poisson distribution; (2) the number of elapsed flight hours between successive independent material failures follows an exponential distribution; (3) the expected number of monthly material failures is exactly proportional to monthly flight hours; and (4) the observed number of monthly material failures is strongly correlated with monthly flight hours. By a well-known result, hypotheses (1) and (2) are equivalent. By a second well-known result, hypotheses (1) and (3) are also equivalent. However, hypotheses (1) and (4) are not equivalent. That is, while the expected number of failures is exactly proportional to flight hours under a Poisson distribution, this relationship is not revealed by a linear regression between failures and flight hours. For example, we demonstrate that if the mean and variance of flight hours across months are equal and if the failure rate per flight hour equals .01, then the correlation between failures and flight hours will equal .10. GRA

**N86-15449#** Joint Publications Research Service, Arlington, Va.

**MBB STUDIES VARIABLE-CAMBER WING FOR AIRBUS**

*In its* West Europe Report: Science and Technology (JPRS-WST-85-024) p 20-21 13 Aug. 1985 Transl. into ENGLISH from MBB Aktuell (West Germany), Feb. 1985 p 3
Avail: NTIS HC A04/MF A01

A program is described that encompasses the application of variable camber to a transonic wing in long-distance aircraft such as the Airbus. The task is to configure previously employed flaps for variable camber use over the entire wing span. R.J.F.

**N86-15450#** Joint Publications Research Service, Arlington, Va.

**FRENCH PROGRAM CHARME DEVELOPS PROPFAN AIRCRAFT**

*In its* West Europe Report: Science and Technology (JPRS-WST-85-024) p 22-24 13 Aug. 1985 Transl. into ENGLISH from AFP Sciences (Paris), 14 Mar. 1985 p 25-27
Avail: NTIS HC A04/MF A01

France has decided to begin studies on future engines for heavy cargo propeller planes. The first research in France started around 1978, three years after the American Hamilton Standard (of the United Technologies group, which also owns Pratt and Whitney). The French studies are currently carried out as part of the Propeller Design for Fast Plane for Greater Economy (CHARME) program. The French government prefers the term fast plane propeller instead of the American names Propfan, Freefan, or Unducted Fan (UDF) of General Electric. A test of a new propeller, perfected in France and consisting of 12 blades, is scheduled for September 1985 in a wind tunnel which will model flight conditions. This test is intended to determine the noise level of this propeller. R.J.F.

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-16858**

**EVALUATION OF TAPE RECORDINGS FROM AN AIRBORNE DIGITAL RECORDER [VYHODNOCOVANI MAGNETICKYCH ZAZNAMU Z PALUBNIHO CISLICOVEHO ZAPISOVACE]**

J. STEPANOVSKY Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 91-95. In Czech.

A ground-based computerized system for evaluating magnetic tape recordings made by an onboard digital recorder is described. In particular, attention is given to the operation of the computer and its peripherals. The software used in the system is analyzed from the standpoint of the support of computer and onboard recorder functions and from the standpoint of the user. V.L.

**A86-16862**

**THE POSSIBILITY OF USING A FLIGHT RECORDER FOR THE ANALYSIS OF PILOT PERFORMANCE [MOZNOSTI VYUZITI PALUBNIHO ZAPISOVACE K ANALYZE CINNOSTI PILOTA]**

L. ODSTRCIL Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 109, 110. In Czech.

It is shown how a flight recorder can be used for the analysis of the performance of the crew during the flight in order to obtain information useful in the flight training process. A segment analysis of individual flight stages is recommended as an optimum approach. The use of a recorder is particularly effective with flight simulators since pilot performance can be evaluated immediately following a flight stage or a particular flight situation that is being practiced. V.L.

**A86-17172**

**BIG PICTURE - ANSWER TO THE BIG PROBLEM?**

K. WALKER Flight International (ISSN 0015-3710), vol. 128, Nov. 2, 1985, p. 22-24.

'Big Picture' is an experimental fighter cockpit instrument system whose large area display entirely replaces the conventional instrument panel. Big Picture will apprise pilots of enemy aircraft positions, those of friendly aircraft, air-to-air and surface-to-air missile threats, and terrain, on a 300-400 sq in screen which is touch-sensitive to permit selection of different data types. Helmets incorporating brain activity sensors that could be used to actively control the display are under development in conjunction with Big Picture. O.C.

**A86-17524**

**AVIONICS UPDATE 1986**

M. HIRST Air International (ISSN 0306-5634), vol. 29, Dec. 1985, p. 283-286.

A development trend and performance improvement evaluation is conducted for state-of-the-art U.S. and West European military avionics, encompassing sensors, signal processors, and user systems. Laser radar, or lidar, is noted to be the critical emerging technology in jam-resistant active sensors for target identification and navigation. Digital signal processor miniaturization achievements are highlighted, together with improvements in cockpit CRT displays. A closing, speculative assessment of prospects for the application of machine intelligence to future avionics is included. O.C.

**A86-18407**

**FLIGHT DATA ANALYSIS AND STORAGE SYSTEM (FASS)**

B. STOCKER, E. W. SPENCER, and R. SULINSKI (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

While the Real-time Acquisition and Processing of Inflight Data system is an effective tool for the acquisition, processing and storage of inflight measurements, the great volume and variety of data recorded for each flight has rendered responsive data access difficult except on a single-flight basis. Accordingly, the Flight Data Analysis and Storage structural statistics library has been developed to accumulate data over the course of an entire flight test program, greatly improving data retrieval capability. This represents an 80-percent reduction in manhours spent in assembling in-flight measurements for component fatigue substantiation. O.C.

**A86-18423**

**A STRUCTURED APPROACH FOR INTEGRATION AND TEST OF AVIONICS SYSTEMS**

J. M. MEDWETZ (IBM Corp., Federal Systems Div., Owego, NY) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 11 p.

Much of the process of contemporary avionics system development involves assembling system elements, achieving integrated function, and validating performance. In the case of complex systems, the efficiency required in integration and testing efforts can be enhanced by ensuring that system specifications are testable before they become binding, by applying computer data base capabilities that can furnish a matrix for the definition of well organized test/development approaches and for the monitoring of progress, and by employing efficient data collection schemes. The effectiveness of these recommendations is noted in their application to the U.S. Navy's Light Airborne Multi-Purpose System. O.C.

**A86-18435**

**US ARMY FLIGHT CONDITION MONITORING**

R. L. BUCKNER and D. J. MERKLEY (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 5-1 to 5-15. refs

The Flight Condition Monitoring (FCM) method of acquiring operational usage data is presented as it was developed from U.S. Army helicopter service usage programs from 1964 to present. The importance of incorporating operational usage data in fatigue design approaches, such as Safe-Life and Damage Tolerance, is discussed with emphasis on the establishment of dynamic component fatigue lives. The Army's service usage programs are critically reviewed to determine areas of sensitivity in establishing design mission spectra for rotary-winged aircraft. The feasibility of utilizing FCM with state-of-the-art microprocessor recorder technology on future in-service programs is presented with suggested unified approaches to mission spectrum development on current and future helicopter systems. Author

**A86-18451**

**SPECIALISTS' MEETING ON ADVANCED COCKPIT DESIGN, GRAPEVINE, TEX, OCTOBER 3, 4, 1984, PROCEEDINGS**

Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1984, 211 p. For individual items see A86-18452 to A86-18465.

The present conference on helicopter avionics discusses analytical methods for LHX mission and task analysis, Standard Helicopter Abstract Mission Simulation, a wide angle, low altitude flight simulator vision system for cockpit research and aircrew training, LED displays, thin film electroluminescent displays, the use of a stored topographic data base in modern military helicopters, and head-mounted displays. Also considered are 'virtual cockpit' concepts for the LHX, panoramic display techniques for the LHX, aspects of integrated cockpit information displays, specific differences arising in future helicopter cockpit designs due to civil and military requirements, the operational impact of night vision devices, electroluminescent lighting for the AH-64A helicopter, and the use of interactive voice systems in military helicopters. O.C.

**A86-18455**

**OVERVIEW OF ADVANCED DISPLAY TECHNOLOGIES**

J. R. TRIMMIER (Sperry Corporate Technology Center, Phoenix, AZ) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 16 p.

The large volume of latent information in advanced digital aircraft systems has required the development of displays for selective presentation only the most pertinent information. Attention is presently given to display technologies whose volume represents a significant reduction from that of the conventional CRT. The most promising systems are liquid crystal displays thin film ac electroluminescent panels, matrix LEDs, vacuum fluorescent panels, ac plasma panels, and flat and 'shadow mask' CRTs. O.C.

**A86-18456**

**A THIN FILM ELECTROLUMINESCENT DISPLAY FOR COCKPIT APPLICATIONS**

G. L. VICK, J. P. SHEPHARD, W. G. RUNYAN, and J. S. TRCKA (Rockwell International Corp., Cedar Rapids, IA) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 12 p.

For aircraft cockpit applications, thin films electroluminescent (TFEL) flat panel displays must be sunlight-readable and sufficiently rugged to sustain combat mechanical, thermal, and other stresses. In addition, panel reflectivity must be lower than for conventional applications. Attention is presently given to a TFEL system developed for the A-10 ground support aircraft, with a view to its display driver control circuitry, display memory, character interface circuitry, and power supply design. Preliminary results are presented. O.C.

**A86-18458**

**ADVANCED LIGHT EMITTING DIODE (LED) DISPLAYS-PACED BY TECHNOLOGY OR SYSTEMS APPLICATION?**

J. WRIGHT (Litton Systems Canada, Ltd., Rexdale, Canada) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 21 p.

Attention is given to the development prospects and drivers of LED display surfaces fabricated by means of discrete, die displacement/wire-bonding techniques, containing integrated serial data interface/decode capability together with associated current sources and sinks. Chromatic, resolution and preceptual characteristics are treated, along with dimensional limits, thermal and power consumption characteristics, and likely cost/performance tradeoffs. Predictions cited are based on development data generated in the course of the last eight years, therefore possessing a high confidence factor for the next 3-4 years. O.C.

**A86-18459**

**USE OF A STORED TOPOGRAPHIC DATA BASE IN THE MODERN MILITARY HELICOPTER**

K. P. GIBBS and J. A. GRACIA (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 10 p.

A stored topographical data base may be employed to significantly enhance military helicopter pilot efficiency while reducing workloads. Geographic orientation is automated by furnishing a plan view map with a helicopter position symbol; terrain correlation eliminates the need for position updating and facilitates autonomous navigation, especially in nap-of-the-earth flying. The stored data base also provides a look-ahead capability from cover that is especially useful when presented in a perspective format. The storage of elevation values is directly applicable to terrain following/terrain avoidance. O.C.

**A86-18460**

**HMD: GLOBAL HUD SOLUTION**

D. J. ROTIER (Honeywell, Inc., Avionics Div., St. Louis Park, MN) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 14 p.

A comparative assessment is made of candidate Helmet Mounted Display (HMD) system configurations for single crew member helicopter night flying, giving attention to aircraft loss probability in a high threat combat environment due to system failures, and to the achievement of a minimum head-supported weight value for a system that furnishes the requisite display system redundancy. Both monocular/binocular HMD systems are considered, as are combined monocular/binocular, image intensifier-based, and night vision goggles-based systems. Redundant sensors are noted to be required for combat safety and mission effectiveness. O.C.

**A86-18461**

**HELICOPTER COCKPIT AVIONICS DEVELOPMENT OR THE ADVANCED TRANSPORT AND NEXT GENERATION AIRCRAFT**

C. SCOUGHTON, R. JOHNSTON, and R. COHEN (Bendix Aerospace Sector, Flight Systems Div., Teterboro, NJ) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 28 p.

Significant advances are currently being made in cockpit technology. One advanced cockpit design currently under development by Bendix provides a fully integrated avionics management approach for a new technology military transport helicopter. However, for next generation helicopters such as the Army's LHX, innovative new approaches are required to provide a tighter coupling between pilot and aircraft. An overview of the avionics management system being developed for the Boeing-Vertol Model 360 is presented with emphasis on crew assist functions to reduce stress and increase overall crew efficiency. This is followed with a discussion of crew station drivers, requirements, and technologies for a next generation cockpit solution. Author

**A86-18463**

**HUGHES HELICOPTERS AH-64A ELECTROLUMINESCENT LIGHTING**

T. C. KNIGHT and J. E. RITTER (Hughes Helicopters, Inc., Culver City, CA) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 20 p. refs

Favorable experience with electroluminescent formation lights and natural compatibility with night vision devices led to Electroluminescent Light as a consideration for secondary cockpit illumination. Electroluminescence provides a cool, flat, dependable, low-level light source. The brightness is uniform overall and it casts no shadows. The most efficient light output is blue-green. This is also the color that is most effective with night vision goggles, cathode ray tubes and other night vision aids. The equipment and the relationship to cockpit lighting and night vision will be examined. It meets or exceeds applicable military standards. This new application offers an opportunity to extend the technology into an area certain to be used heavily in the future. Author

**A86-18464**

**DISPLAY FORMATS AND INFORMATION TRANSFER REQUIREMENTS AS THEY RELATE TO MISSION, AIRCREW AND AIRCRAFT TYPE**

J. RASINSKI (Sperry Corp., Commercial Flight Systems Div., Phoenix, AZ) and J. EMERY (Bell Helicopter Textron, Fort Worth, TX) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 18 p.

A study is conducted of the character of cockpit data display format and information transfer requirements that are driven by fixed or rotary wing aircraft type, mission requirements, and aircrew size, as in the cases of the OH-58 helicopter and OV-1 aircraft. Attention is given to the modification of the former's helicopter control display system for use by the latter. Emphasis is placed on the difficulties encountered as a result of the strict use of OH-58 displays. O.C.

**A86-18552**

**TOWARD AN AVIONICS SUPERSYSTEM**

Defense Electronics (ISSN 0278-3479), vol. 17, Dec. 1985, p. 73, 75, 77 (4 ff.).

Design features, performance objectives and development status assessments are presented for the U.S. Air Force's Pave Pillar program, which has as its goal the creation of a central computer/multiplex bus architecture for a single modular avionics system integrating communications, navigation, targeting, fire control, offensive and defensive EW, and systems status monitoring functions. Attention is given to the Pave Pillar components designated 'Integrated Electronic Warfare System' and 'Low Altitude Navigation and Targeting IR system for Night' (LANTIRN). LANTIRN furnishes tactical strike aircraft with day/night all-weather high speed/low altitude flight and weapons delivery capabilities, and is to be deployed on F-15E, F-16C/D, and A-10 aircraft. The current status of the Airborne Self-Protection Jammer system is assessed. O.C.

**A86-18694**

**THE EVOLUTION OF THE COCKPIT DISPLAYS IN COMMERCIAL AIRLINES [EVOLUTION DU POSTE DE PILOTAGE DES AVIONS DE LIGNE]**

J. CASTIES (Thomson-CSF, Division Equipements Avioniques, Malakoff, France) Navigation (Paris) (ISSN 0028-1530), vol. 33, Oct. 1985, p. 399-408. In French.

The development of high resolution CRTs has led to the installation of digitized information displays in instrument panels of passenger aircraft. Integrated circuits provided the necessary reliability and image clarity for ensuring flight safety. The devices were first used in simulators for the Concorde and then for flight hardware on the 757 and 767 aircraft. Shadow-mask technology, being implemented for the new generation of Airbus vehicles, has sufficient stability due to the electron gun alignment configuration that the technology is being tested for use in helicopters, which experience high vibration levels. The new avionics displays furnish navigation, aircraft control and flight management information, including digitized maps, meteorological and radar data. Data can be split into two screens, one for status displays and another for checklist procedures for, e.g., compensating for a malfunction. The avionics on the Airbus 320, scheduled for delivery in 1988, will feature a common computer for the displays and a mini-controller for directing the aircraft. Directions being taken to introduce AI into the avionics are briefly discussed. M.S.K.

**A86-18743**

**INFORMATION-MEASUREMENT COMPLEXES OF FLIGHT VEHICLES [KOMPLEKSIROVANIE INFORMATSIONNO-IZMERITEL'NYKH USTROISTV LETATEL'NYKH APPARATOV]**

IU. P. IVANOV, A. N. SINIAKOV, and I. V. FILATOV Leningrad, Izdatel'stvo Mashinostroenie, 1984, 208 p. In Russian. refs

The concept of information-measurement complexes is defined, and the principles governing the synthesis of such complexes are presented along with their classification. The statistical characteristics of the main instruments in an information-measurement complex are then analyzed, and mathematical models are developed which describe measurements in time and frequency domains and also in state space in accordance with the specific characteristics of measurements on a flight vehicle. Further, the discussion focuses on the principal properties of estimates, the structure of a multichannel complex system, synthesis of optimal linear complex measurement systems, and inertialess nonlinear optimal complex measurement systems. Finally, complex data processing in the control systems of elastic flight vehicles is examined. V.L.

**N86-14270#** National Aerospace Lab., Tokyo (Japan).

**DYNAMIC CHARACTERISTICS OF AIR DATA SENSOR SYSTEMS: ALTIMETER, SPEEDOMETER AND ALPHA X BETA VANE**

Y. TSUKANO and T. ONO 1985 20 p refs In JAPANESE; ENGLISH summary

(NAL-TR-852; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

Dynamic response characteristics of air-data-sensor systems including a pressure altitude sensor, a dynamic pressure sensor and a alpha beta vane are described in this paper. These air data sensors are currently used as part of instrumentation systems for the Variable Stability and Response Airplane (VSRA). Responses of the pressure sensor system to stepwise inputs from both static and total pressure ports were measured and analyzed to identify the dynamic model of the system, which is assumed to be linear. Response of a alpha beta vane to initial displacement were measured in a 2 m diameter wind tunnel at wind speeds from 30 m/s to 55 m/s and the assumed dynamic model including weak nonlinearity was identified. Author

**N86-15312#** National Aerospace Lab., Tokyo (Japan).

**DYNAMIC CHARACTERISTICS OF AIR DATA SENSOR SYSTEMS: ALTIMETER, SPEEDOMETER AND ALPHA TIMES BETA VANE**

Y. TSUKANO and T. ONO 1985 20 p refs In JAPANESE; ENGLISH summary

(NAL-TR-852; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

Dynamic response characteristics of air-data-sensor systems including a pressure altitude sensor, a dynamic pressure sensor and a alpha-beta vane are described in this paper. These air data sensors are currently used as part of instrumentation systems for the Variable Stability and Response Airplane (VSRA). Responses of the pressure sensor system to stepwise inputs from both static and total pressure ports were measured and analyzed to identify the dynamic model of the system, which is assumed to be linear. Response of a alpha-beta vane to initial displacement were measured in a 2 m diameter wind tunnel at wind speeds from 30 m/s and the assumed dynamic model including weak nonlinearity was identified. Author

**N86-15947#** Joint Publications Research Service, Arlington, Va.

**WORK ON PUTTING COMPUTER AND CRTS IN AIRLINER CONTROL PANELS**

V. TSEYUKOV *In its* USSR Report: Cybernetics, Computers and Automation Technology (JPRS-UCC-85-009) p 25-26 19 Nov. 1985 Transl. into ENGLISH from Vozdushnyy Transport (Moscow, USSR), 17 Aug. 1985 p 3

Avail: NTIS HC A04

The controls of airplanes of the future will have far fewer electro-mechanical devices. Such devices and dozens of dials and lights will be replaced by the screen of a cathode-ray tube. The development of this kind of integrated information-signaling system is now in progress. With aviation technology advancing rapidly, aircraft systems are becoming more complex, and the most important ones have back-up systems. It is not easy for a pilot to control an aircraft and interact with instruments and devices. The new system will make it possible to remove a portion of the devices that are located directly in front of the pilot, and to remove all the devices from the flight engineer's panel. Needed information on the operation of all of the airplane's maintenance systems and several of its main units will be concentrated in a single place--on the color screens of cathode-ray tubes in the center of the instrument panel. Author

# 07

# AIRCRAFT PROPULSION AND POWER

**Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.**

**A86-17490**

**COATING REQUIREMENTS IN GAS TURBINE ENGINES**

G. W. MEETHAM (Rolls-Royce, Ltd., Derby, England) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 3, Nov.-Dec. 1985, p. 2509-2515. refs

Four types of coatings, with special emphasis on their use in gas turbine engines, are discussed. First, a corrosion resistant coating, aluminide, is considered. It is found that aluminide coatings on engines used in salt contaminated environments improved the corrosion resistance; however, the use of a coating thickness above specification caused brittle cracking of the aluminide coat which could propagate into the base material. Then, thermal barrier coatings based on the low thermal conductivity of ZrO2 are examined. It is shown that the replacement of an initial three-layer coating by a two-layer coating brought about major improvements in the temperature capability and the thermal fatigue resistance of the engines; a fourfold in thermal resistance is achieved. Finally, wear resistance and abradable coatings are addressed, determining that shrouds on turbine rotor blades form a very effective gas path seal and contribute very significantly to turbine efficiency. Although in the past coatings have been regarded as 'post design bolt-on features', they are now part of the design process. F.J.

**A86-17491**

**FLAME RIG TESTING OF THERMAL BARRIER COATINGS AND CORRELATION WITH ENGINE RESULTS**

G. JOHNER and K. K. SCHWEITZER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 3, Nov.-Dec. 1985, p. 2516-2524. refs

To minimize detrimental thermal stresses in high-performance aeroengines, attempts are made to protect hot components, e.g., combustion chambers, blades, vanes, etc., with plasma-sprayed zirconia coatings. In the present evaluation, the best coating material is first defined using an appropriate rig test. Two different types of test rig, one simulating mainly thermal fatigue stresses and the other centrifugal stresses, are described in detail. The results obtained in each rig with thermal barrier coatings of different chemical composition are also discussed. For the application of thermal barrier coatings in aeroengines, it is necessary to analyze the main stresses on the component to be coated. The paper uses a turbine vane and a blade as examples. In addition, another flame rig is presented which permits the simulation of stresses very similar to those in jet engines. The results of these tests are compared with the behavior of thermal barrier coatings on turbine blades and vane segments in a production-type engine. Author

**A86-17750**

**THE V2500 ENGINE**

W. H. GOODMAN Exxon Air World, vol. 37, no. 3, 1985, p. 16-20.

An account is given of the design features and performance objectives of the new generation V2500 25,000-lb thrust high bypass turbofan engine for 150-seat airliners, with attention to the apportionment and management of development and construction responsibilities among a total of seven companies from five countries. These companies, which are from Britain, Germany, Italy, Japan, and the U.S., collectively form International Aero Engines, which is incorporated in Switzerland. Emphasis is given to the economic advantages and costs of international collaboration, and to the issue of technology transfer among companies that are normally competitors. O.C.

**A86-17777#**

**PROPULSION SYSTEM INTEGRATION CONFIGURATIONS FOR FUTURE PROP-FAN POWERED AIRCRAFT**

J. GODSTON and C. H. REYNOLDS (United Technologies Corp., Pratt and Whitney, East Hartford, CT) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1027-1033. Previously cited in issue 17, p. 2469, Accession no. A83-38081. refs

**A86-17784*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**FLIGHT EVALUATION OF A DIGITAL ELECTRONIC ENGINE CONTROL IN AN F-15 AIRPLANE**

F. W. BURCHAM, JR., L. P. MYERS, and K. R. WALSH (NASA, Flight Research Center, Edwards, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1072-1078. Previously cited in issue 02, p. 134, Accession no. A84-12310. refs

**A86-17829#**

**PROPULSION FOR ADVANCED COMMERCIAL TRANSPORTS**

A. ADAMSON and A. R. STUART (General Electric Co., Fairfield, CT) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 6 p. (AIAA PAPER 85-3061)

The Unducted Fan concept sponsored by General Electric Company in conjunction with NASA Lewis Research Center is discussed. Some of the events leading to its creation are reviewed, the current status is given, and the prospects for future applications are described. Some of the potential technical problems and the status of efforts to find solutions are presented. Author

**A86-17843#**

**THE INFLUENCE OF FORWARD FLIGHT ON THRUST AUGMENTING EJECTORS**

A. KROTHAPALLI, L. VAN DOMMELEN (Florida State University, Tallahassee), and K. KARAMCHETI (Stanford University, CA) AIAA, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs (AIAA PAPER 85-1589)

A theoretical analysis is carried out for the flow through a constant area ejector in the presence of a uniform free stream. It is shown that multiple solutions can occur. However, only those which fulfill the entropy condition are considered. For subsonic flight Mach numbers, it is found that the thrust augmentation ratio decreases rapidly with increasing free stream Mach number. In the supersonic range of flight Mach numbers, two solutions were found, one with a relatively large augmentation ratio and the other with an augmentation ratio close to unity. The nature of the different solutions is explained. In addition, their dependence on various parameters, such as pressure, temperature and area ratios was investigated. Author

**A86-18725**

**TURBOFAN ENGINES FOR COMMERCIAL AIRCRAFT [ZWEISTROMTRIEBWERKE FUER VERKEHRSFLUGZEUGE]**

E. SCHESKY (Dresden, Hochschule fuer Verkehrswesen, East Germany) Technisch-Oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 5, 1985, p. 192-194. In German. refs

Schesky (1973) has discussed the development of engines for commercial aircraft. The present article is concerned with the continuation of this development during the preceding 15 years, taking into account also predictions for the next 15 years. Only jet turbine engines for the air traffic are considered. A classification of jet turbine engines is presented. It is pointed out that turbofan engines with a high bypass ration represent currently the most important category for commercial flight applications. Attention is given to the state of development of these engines at about 1970, the current state of development, and development trends. It is found that very significant advances with respect to turbofan engines have been made since 1960. However, there remain possibilities for further improvement, in particular with regard to the utilization of new materials. G.R.

**A86-18745**
**HEAT TRANSFER IN COOLED PARTS OF AIRCRAFT GAS-TURBINE ENGINES [TEPLO-PEREDACHA O OKHLAZHDAEMYKH DETALIAKH GAZOTURBINNYKH DVIGATELEI LETATEL'NYKH APPARATOV]**
V. I. LOKAI, M. N. BODUNOV, V. V. ZHUIKOV, and A. V. SHCHUKIN Moscow, Izdatel'stvo Mashinostroenie, 1985, 216 p. In Russian. refs

The principal aspects of heat transfer in the turbines, compressors, and combustion chambers of the gas-turbine engines of aircraft are examined. In particular, experimental data are presented on heat transfer between the working medium and the blading of a gas-turbine engine and heat transfer in the blade cooling channels and on the surface of turbine and compressor rotors. Methods are then presented for calculating the hydraulic resistances of the cooling system and the temperature field of gas-turbine engine components under stationary and nonstationary conditions. V.L.

**A86-19198*** Pennsylvania State Univ., University Park.
**STABILITY OF LIMIT CYCLES IN FRICTIONALLY DAMPED AND AERODYNAMICALLY UNSTABLE ROTOR STAGES**
A. SINHA (Pennsylvania State University, University Park) and J. H. GRIFFIN (Carnegie-Mellon University, Pittsburgh, PA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 103, Dec. 8, 1985, p. 341-356. refs
(Contract NAG3-231)

This paper deals with the stability of limit cycles (Steady-State Oscillations) associated with the multi-degree-of-freedom model of a frictionally damped and aerodynamically unstable rotor stage. By using the first order averaging technique, a generalized criterion has been established to sort out those unstable limit cycles which govern the maximum transient amplitude beyond which the rotor stage becomes unstable.The stability of the remaining steady-state solutions is analyzed by linearizing the averaged system of differential equations. Numerical results are discussed for three-, four- and five-bladed disks. Author

**A86-19278**
**NATURAL SELECTION IN TRANSPORT AIRCRAFT PROPULSION**
P. SMITH (British Aerospace, PLC, Aircraft Group, Hatfield, England) and D. JAGGER (Airbus Industries, Blagnac, France) Aerospace (UK) (ISSN 0305-0831), vol. 12, Dec. 1985, p. 10-12.

An evaluation is made of current and prospective airliner propulsion system configurations which differ as to both number (and position) of engines and engine type (high bypass turbofan or turboprop/propfan). Attention is given to the comparative operating costs, efficiency and safety of two-, three-, and four-engine configurations for the case of cruise ranges as great as 6000 nm. The efficiency and safety gains projected for turboprops are discussed in view of the various aircraft sizes and ranges typical of alternative airliner mission types. O.C.

**N86-14271*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
**TURBINE BLADE THERMAL FATIGUE TESTING PRATT AND WHITNEY AIRCRAFT HOLLOW CORE BLADES**
J. INGRAM and L. GROSS Sep. 1985 18 p
(NASA-TM-86528; NAS 1.15:86528) Avail: NTIS HC A02/MF A01 CSCL 21E

The results of low cycle fatigue testing on turbine blades for use in hydrogen/oxygen rocket engines is presented. Cored blade and cored blades with circulation were tested in the MSFC thermal fatigue tester. Both blade configurations showed significant low cycle fatigue life improvements when compared to baseline solid blades. Author

**N86-14272*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
**PRELIMINARY DESIGN OF A SUPERSONIC CRUISE AIRCRAFT HIGH-PRESSURE TURBINE Final Report**
L. D. ACETO and J. C. CALDERBANK 2 Nov. 1983 128 p refs
(Contract NAS3-20357)
(NASA-CR-174878; NAS 1.26:174878; PWA-5923-14) Avail: NTIS HC A07/MF A01 CSCL 21E

Development of the supersonic cruise aircraft engine continued in this National Aeronautics and Space Administration (NASA) sponsored Pratt and Whitney program for the Preliminary Design of an Advanced High-Pressure Turbine. Airfoil cooling concepts and the technology required to implement these concepts received particular emphasis. Previous supersonic cruise aircraft mission studies were reviewed and the Variable Stream Control Engine (VSCE) was chosen as the candidate or the preliminary turbine design. The design was evaluated for the supersonic cruise mission. The advanced technology to be generated from these designs showed benefits in the supersonic cruise application and subsonic cruise application. The preliminary design incorporates advanced single crystal materials, thermal barrier coatings, and oxidation resistant coatings for both the vane and blade. The 1990 technology vane and blade designs have cooled turbine efficiency of 92.3 percent, 8.05 percent Wae cooling and a 10,000 hour life. An alternate design with 1986 technology has 91.9 percent efficiency and 12.43 percent Wae cooling at the same life. To achieve these performance and life results, technology programs must be pursued to provide the 1990's technology assumed for this study. Author

**N86-14274#** Joint Publications Research Service, Arlington, Va.
**AN-22 TEST BED FOR ADVANCED PROPELLER TECHNOLOGY**
V. BELIKOV *In its* USSR Report: Transportation (JPRS-UTR-85-012) p 22-23 24 Oct. 1985 Transl. into ENGLISH from Izvestiya (Moscow), 12 Jul. 1985 p 1 and 6
Avail: NTIS HC A06

The technological and historical development of the turbofan engine is described. Designers and scientists have given birth to a multiple-bladed propeller which has been named the fan propeller. Flight tests carried out with the fan propeller on the AN-32 aircraft have resulted in increased fuel consumption and greater flying speed. Less noise and vibration problems were reported with the new propellers. B.W.

**N86-15313*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**DYNAMIC RESPONSE OF FILM THICKNESS IN SPIRAL-GROOVE FACE SEALS**
E. DIRUSSO Dec. 1985 22 p refs
(NASA-TP-2544; E-2683; NAS 1.60:2544) Avail: NTIS HC A02/MF A01 CSCL 21E

Tests were performed on an inward- and an outward-pumping spiral-groove face seal to experimentally determine the film thickness response to seal seat motions and to gain insight into the effect of secondary seal friction on film thickness behavior. Film thickness, seal seat axial motion, seal frictional torque, and film axial load were recorded as functions of time. The experiments revealed that for sinusoidal axial oscillations of the seal seat, the primary ring followed the seal seat motion very well. For a skewed seal seat, however, the primary ring did not follow the seal seat motion, and load-carrying capacity was degraded. Secondary seal friction was varied over a wide range to determine its effect on film thickness dynamics. The seals were tested with ambient air at room temperature and atmospheric pressure as the fluid medium. The test speed ranged from 7000 to 20,000 rpm. Seal tangential velocity ranged from 34 to 98 m/sec (113 to 323 ft/sec). Author

**N86-15315#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**ANALYSIS OF THE EFFECTS OF TRANSIENT HEAT TRANSFER ON AXIAL FLOW COMPRESSOR BLADE BOUNDARY LAYERS M.S. Thesis**

C. W. WOOD Jun. 1985 69 p
(AD-A158094; AFIT/CI/NR-85-87T) Avail: NTIS HC A04/MF A01 CSCL 21E

This thesis determines the magnitude of heat transfer in the high-pressure compressor of a turbofan engine during a Bodie throttle transient and estimates the effect of transient heat transfer on compressor blade boundary layer growth. Total stored thermal energy available for release is determined considering compressor blades and roots only. Thermal energy released during a throttle transient is determined and allocated to individual compressor stages and used to estimate blade heat flux. The average heat transfer coefficient at the maximum heat transfer rate is also calculated. A simple boundary layer analysis is performed assuming zero pressure gradient, compressible turbulent flow over a flat plate. Under free-stream conditions similar to those in the tenth stage of the compressor, this analysis shows increased boundary layer displacement thickness with heat transfer. In zero pressure gradient, the displacement thickness change with heat transfer is small, as is the change in flow deviation angle at the trailing edge of the compressor blade. Heat transfer coefficients are also calculated in the boundary layer analysis and agree with results from the experimental heat transfer allocation procedure to within 30%. Results of boundary layer analysis indicate assumptions made in heat transfer allocation procedure are reasonable and that simple boundary layer analysis with the absence of modifying pressure gradients provides a good first estimate of heat transfer effects on blade boundary layers. GRA

**N86-15316#** Institute for Defense Analyses, Alexandria, Va.

**SMALL TURBINE TECHNOLOGY REVIEW Final Report, Feb. - Dec. 1984**

I. C. OELRICH, D. D. WEIDHUNER, and F. R. RIDDELL Jul. 1985 91 p
(Contract MDA903-84-C-0031)
(AD-A158514; AD-E500724; IDA-P-1840; IDA/HQ-85-29944)
Avail: NTIS HC A05/MF A01 CSCL 21E

This study, for OUSDRE (Research and Advanced Technology, Military Systems Technology), examines the nature of the small gas turbine development process for military applications, attempts to identify gaps between current programs and probable future needs, and makes program recommendations for acquiring desirable new turbine technology. Small turbines are found to fall into one of four categories: man-rated, expendable, auxiliary power, and ground vehicle engines. The technical requirements of each category are reviewed and possible R&D opportunities identified. GRA

**N86-15317#** Department of the Air Force, Washington, D.C.

**RESONANT CAVITIES FOR STALL RECOVERY IN GAS TURBINE ENGINES Patent Application**

FRENCH, inventor (to Air Force) 23 Jul. 1985 20 p
(AD-D011891; US-PATENT-APPL-SN-757994) Avail: NTIS HC A02/MF A01 CSCL 21E

The present patent application is related generally to aircraft which use gas turbine engines as a means of propulsion, and specifically to a means for improvement in the stall recoverability characteristics of such gas turbine engines through the use of resonant cavities. The ability of gas turbine engines to recover when their compressors enter a rotating stall is enhanced with the accessing resonant cavity to the compressor exhaust port. The added volume of the resonant cavities induces a dynamically unstable operating point in the rotating stall as the cavity acts as a Helmholtz resonator matched with the dynamics of the primary flow. The resonant cavity is effective in enhancing the stall recovery characteristics of the engine. GRA

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-16787**

**STABILITY OF THE STEADY-STATE GLIDING OF A FLIGHT VEHICLE [OB USTOICHIVOSTI STATSIONARNOGO REZHIMA PLANIROVANIIA LETATEL'NOGO APPARATA]**

O. IU. CHERKASOV Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), Sept.-Oct. 1985, p. 80-83. In Russian.

The paper is concerned with the stability of the steady-state gliding of a plate model of a flight vehicle for the case of an arbitrary angle between the resultant of the aerodynamic forces and the plate. For assumptions that are more general than those made in the well-known Zhukovskii problem (Zhukovskii, 1948), it is shown that wave-like and loop-like trajectories tend to stable gliding. V.L.

**A86-17175**

**FOR AGILE READ ACTIVE**

G. WARWICK Flight International (ISSN 0015-3710), vol. 128, Nov. 9, 1985, p. 29-31.

Agility is defined as a combination of vehicle performance and handling qualities enabling rapid and precise changes in helicopter position or flight path; it is a function of excess rotor thrust available together with the speed of redirection. Attention is presently given to the necessity of developing military helicopter 'test bed' vehicles with which to explore and refine novel high agility technologies. Such demonstrator aircraft are especially valuable in answering questions associated with nap-of-the-earth flight, where agility is most critical. Fly-by-wire, sidestick pilot controls and automatic flight controls are among the candidate technologies for development and demonstration programs. O.C.

**A86-18465**

**SYSTEM PARTITIONING TO PROVIDE FOR AUTOMATIC MISSION AND VEHICLE MANAGEMENT**

B. W. KOTH and J. A. GRACIA (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 9 p. refs

In order to support the single crew member stipulated for the 'LHX' U.S. Army next-generation helicopter, parallel channels of information must be processed concurrently; also, many of the routine aircraft management tasks will have be automated in order to minimize pilot workload. System partitioning will be introduced in the course of avionics development in order to accommodate design updates made possible by technological advancements. Attention is given to the Automatic System Manager subsystem, which handles all crew/system interfaces. O.C.

**A86-18987**

**SPATIAL ORIENTATION OF AN AIRCRAFT DURING THE EXECUTION OF LATERAL MANEUVERS [PROSTRANSTVENNAIA ORIENTATSIIA SAMOLETA PRI VYPOLNENII BOKOVYKH MANEVROV]**

I. A. MIKHALEV and V. G. CHERNYTSHOV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) Priborostroenie (ISSN 0021-3454), vol. 28, Nov. 1985, p. 68-75. In Russian.

The spatial motion of a maneuvering aircraft is studied on the basis of a kinematic analysis in which the aircraft is considered as a rigid body. Formulas are obtained for the angular-orientation parameters as the aircraft executes lateral maneuvers in flight with high attack and sideslip angles. B.J.

**A86-19070#**

**A STUDY OF AIRCRAFT MOTION STABILITY IN STEADY SPIN [BADANIE STATECZNOSCI SAMOLOTU W USTALONYM KORKOCIAGU]**

W. BLAJER (Wyzsza Szkola Inzynierska, Poland) Mechanika Teoretyczna i Stosowana (ISSN 0079-3701), vol. 22, no. 3-4, 1984, p. 445-451. In Polish. refs

A method investigating the stability of aircraft motion in steady spin is presented. The aircraft is treated as a rigid body having six degrees of freedom. The method involves the determination of the eigenvalues of Jacobian matrix of the system of motion equations defined at the equilibrium point. Test calculations have been carried out for the Polish training aircraft TS-11 Iskra. Author

**N86-14275*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DEVELOPMENT OF A FLIGHT TEST MANEUVER AUTOPILOT FOR AN F-15 AIRCRAFT**

G. S. ALAG and E. L. DUKE (Univ. of Western Michigan) Dec. 1985 8 p refs Presented at the 24th IEEE Conf. on Decision and Control, 11 Dec. 1985 Sponsored in part by National Research Council Fellowship

(NASA-TM-86799; H-1328; NAS 1.15:86799) Avail: NTIS HC A02/MF A01 CSCL 01C

An autopilot can be used to provide precise control to meet the demanding requirements of flight research maneuvers with high-performance aircraft. This paper presents the development of control laws for a flight test maneuver autopilot for an F-15 aircraft. A linear quadratic regulator approach is used to develop the control laws within the context of flight test maneuver requirements by treating the maneuver as a finite time tracking problem with regulation of state rates. Results are presented to show the effectiveness of the controller in insuring acceptable aircraft performance during a maneuver. Author

**N86-14276*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A FLIGHTPATH OVERSHOOT FLYING QUALITIES METRIC FOR THE LANDING TASK**

D. T. BERRY Jan. 1986 11 p refs To be presented at the AIAA 24th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1986

(NASA-TM-86795; H-1322; NAS 1.15:86795; AIAA-PAPER-86-0334) Avail: NTIS HC A02/MF A01 CSCL 01C

An analysis was conducted of the attitude and flightpath angle response of configurations used in the Total In-Flight Simulator (TIFS) pitch-rate command systems program. The results show poor correlation between pilot ratings and attitude response and indicate that attitude was not a major influence in the results. A strong correlation was found to exist, however, between the amount of flightpath angle peak overshoot and the pilot ratings. This correlation is similar to the best correlations that have been obtained in recent closed-loop and time-domain analyses but has the advantage of greatly simplified implementation and interpretation. Author

**N86-14277*#** Boeing Commercial Airplane Co., Seattle, Wash. Preliminary Design Dept.

**INTEGRATED APPLICATION OF ACTIVE CONTROLS (IAAC) TECHNOLOGY TO AN ADVANCED SUBSONIC TRANSPORT PROJECT: TEST ACT SYSTEM DESCRIPTION Final Report, Jul. 1981 - Jul. 1983**

Dec. 1983 270 p refs

(Contract NAS1-15325)

(NASA-CR-172221; NAS 1.26:172221; D6-51825) Avail: NTIS HC A12/MF A01 CSCL 01C

The engineering and fabrication of the test ACT system, produced in the third program element of the IAAC Project is documented. The system incorporates pitch-augmented stability and wing-load alleviation, plus full authority fly-by-wire control of the elevators. The pitch-augmented stability is designed to have reliability sufficient to allow flight with neutral or negative inherent longitudinal stability. E.A.K.

**N86-15281*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE USE OF ACTIVE CONTROLS TO AUGMENT ROTOR/FUSELAGE STABILITY**

F. K. STRAUB (Hughes Helicopters, Inc., Culver City, Calif.) and W. WARMBRODT *In its* Rotorcraft Dynamics 1984 p 1-15 Nov. 1985 refs Previously announced in IAA as A85-43220

Avail: NTIS HC A21/MF A01 CSCL 01C

The use of active blade pitch control to increase helicopter rotor/body damping is studied. Control is introduced through a conventional nonrotating swashplate. State variable feedback of rotor and body states is used. Feedback parameters include cyclic rotor flap and lead-lag states, and body pitch and roll rotations. The use of position, rate, and acceleration feedback is studied for the various state variables. In particular, the influence of the closed loop feedback gain and phase on system stability is investigated. For the rotor/body configuration analyzed, rotor cyclic inplane motion and body roll-rate and roll-acceleration feedback can considerably augment system damping levels and eliminate ground resonance instabilities. Scheduling of the feedback state, phase, and gain with rotor rotation speed can be used to maximize the damping augmentation. This increase in lead-lag damping can be accomplished without altering any of the system modal frequencies. Investigating various rotor design parameters (effective hinge offset, blade precone, blade flap stiffness) indicates that active control for augmenting rotor/body damping will be particularly powerful for hingeless and bearingless rotor hubs. Author

**N86-15282*#** Kaman Aerospace Corp., Bloomfield, Conn.

**GROUND RESONANCE ANALYSIS USING A SUBSTRUCTURE MODELING APPROACH**

S. Y. CHEN, E. E. AUSTIN (Applied Technology Lab., Fort Eustis, Va.), and A. BERMAN *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 16-26 Nov. 1985

Avail: NTIS HC A21/MF A01 CSCL 01C

A convenient and versatile procedure for modeling and analyzing ground resonance phenomena is described and illustrated. A computer program is used which dynamically couples differential equations with nonlinear and time dependent coefficients. Each set of differential equations may represent a component such as a rotor, fuselage, landing gear, or a failed damper. Arbitrary combinations of such components may be formulated into a model of a system. When the coupled equations are formed, a procedure is executed which uses a Floquet analysis to determine the stability of the system. Illustrations of the use of the procedures along with the numerical examples are presented. Author

**N86-15283*#** Boeing Vertol Co., Philadelphia, Pa.

**PARAMETRIC STUDY OF THE AEROELASTIC STABILITY OF A BEARINGLESS ROTOR**

W. E. HOOPER *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 27-43 Nov. 1985 refs

Avail: NTIS HC A21/MF A01 CSCL 01C

A trade study was conducted to illustrate the sensitivity of the aeroelastic stability of a bearingless main rotor to the rotor hub coupling parameters that are available for the designer. The results are presented over the complete range of rotor speed and collective pitch available and the effects on air resonance of the 6 beam installation angles are compared together with the results of offsetting the cuff snubber attachment. The major part of the study was conducted using the FLAIR analysis which incorporates a uniform representation of the flexbeam. Results are also shown for a modified version of FLAIR in which the uniform beam is replaced by a member having the geometric tailoring resulting from structural optimization. Author

**N86-15284*#** Duke Univ., Durham, N. C. Dept. of Mechanical Engineering and Material Science.
**NONLINEAR DYNAMICS OF A HELICOPTER MODEL IN GROUND RESONANCE**
D. M. TANG and E. H. DOWELL *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 45-55 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

An approximate theoretical method is presented which determined the limit cycle behavior of a helicopter model which has one or two nonlinear dampers. The relationship during unstable ground resonance oscillations between lagging motion of the blades and fuselage motion is discussed. An experiment was carried out on using a helicopter scale model. The experimental results agree with those of the theoretical analysis. Author

**N86-15286*#** Army Aviation Systems Command, Moffett Field, Calif. Aeromechanics Lab.
**EXPERIMENTALLY DETERMINED FLUTTER FROM TWO- AND THREE-BLADED MODEL BEARINGLESS ROTORS IN HOVER**
W. G. BOUSMAN and S. DAWSON *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 69-88 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

A series of experiments was performed on a 1.8-m-diam model rotor in hover for the principal purpose of investigating the lead-lag stability of isolated bearingless rotors. Incidental to those tests, at least three types of pitch-flap flutter were encountered. Type 1 flutter occurred approximately at the second flap-mode frequency on both two-and three-bladed rotors for both small and large pitch angles and appeared to be a classic pitch-flap flutter. Type 2 flutter showed mostly torsional motion and was seen on both two- and three-bladed rotors. Type 3 flutter was a regressing flap flutter that occurred for only the three-bladed rotor configurations and appears to be a wake excited flutter. Although flutter occurred on a number of different configurations, no rotor parameters were identified that were clearly stabilizing or destabilizing. Author

**N86-15294*#** California Univ., Los Angeles. Dept. of Mechanical, Aerospace and Nuclear Engineering.
**INFLUENCE OF VARIOUS UNSTEADY AERODYNAMIC MODELS ON THE AEROMECHANICAL STABILITY OF A HELICOPTER IN GROUND RESONANCE**
P. P. FRIEDMANN and C. VENKATESAN *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 207-219 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

The aeromechanical stability of a helicopter in ground resonance was analyzed, by incorporating five different aerodynamic models in the coupled rotor/fuselage analysis. The sensitivity of the results to changes in aerodynamic modelling was carefully examined. The theoretical results were compared with experimental data and useful conclusions are drawn regarding the role of aerodynamic modeling on this aeromechanical stability problem. The aerodynamic model which provided the best all around correlation with the experimental data was identified. Author

**N86-15295*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**THE INFLUENCE OF DYNAMIC INFLOW AND TORSIONAL FLEXIBILITY ON ROTOR DAMPING IN FORWARD FLIGHT FROM SYMBOLICALLY GENERATED EQUATIONS**
T. S. R. REDDY and W. WARMBRODT *In its* Rotorcraft Dynamics 1984 p 221-240 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

The combined effects of blade torsion and dynamic inflow on the aeroelastic stability of an elastic rotor blade in forward flight are studied. The governing sets of equations of motion (fully nonlinear, linearized, and multiblade equations) used in this study are derived symbolically using a program written in FORTRAN. Stability results are presented for different structural models with and without dynamic inflow. A combination of symbolic and numerical programs at the proper stage in the derivation process makes the obtainment of final stability results an efficient and straightforward procedure. B.W.

**N86-15296*#** Maryland Univ., College Park. Center for Rotorcraft Education and Research.
**FLAP-LAG-TORSION STABILITY IN FORWARD FLIGHT**
B. PANDA and I. CHOPRA *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 241-258 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

An aeroelastic stability of three-degree flap-lag-torsion blade in forward flight is examined. Quasisteady aerodynamics with a dynamic inflow model is used. The nonlinear time dependent periodic blade response is calculated using an iterative procedure based on Floquet theory. The periodic perturbation equations are solved for stability using Floquet transition matrix theory as well as constant coefficient approximation in the fixed reference frame. Results are presented for both stiff-inplane and soft-inplane blade configurations. The effects of several parameters on blade stability are examined, including structural coupling, pitch-flap and pitch-lag coupling, torsion stiffness, steady inflow distribution, dynamic inflow, blade response solution and constant coefficient approximation. Author

**N86-15297*#** Maryland Univ., College Park. Center for Rotorcraft Education and Research.
**DYNAMIC STABILITY OF A BEARINGLESS CIRCULATION CONTROL ROTOR BLADE IN HOVER**
I. CHOPRA *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 259-271 Nov. 1985
Avail: NTIS HC A21/MF A01 CSCL 01C

The aeroelastic stability of flap bending, lead-lag bending and torsion of a bearingless circulation control rotor blade in hover is investigated using a finite element formulation based on Hamilton's principle. The flexbeam, the torque tube and the outboard blade are discretized into beam elements, each with fifteen nodal degrees of freedom. Quasisteady strip theory is used to evaluate the aerodynamic forces and the airfoil characteristics are represented either in the form of simple analytical expressions or in the form of data tables. A correlation study of analytical results with the experimental data is attempted for selected bearingless blade configurations with conventional airfoil characteristics. B.W.

**N86-15299*#** Sikorsky Aircraft, Stratford, Conn.
**AN EXAMINATION OF THE RELATIONS BETWEEN ROTOR VIBRATORY LOADS AND AIRFRAME VIBRATIONS**
C. F. NIEBANCK *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 287-305 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

Harmonic rotor hub loads and airframe interactions in steady flight are reviewed, with regard to the objective of achieving lower airframe vibration by modifying blade root loads. Flight test and wind tunnel data are reviewed, along with sample fuselage response data. Trends which could provide a generalized approach to the above objective are found to be very limited. Recent analytical and corresponding experimental blade tuning modifications are reviewed and compared. Rotor vibratory load modification and substantial vibration changes were achieved over a wide range of rotor operating conditions. B.W.

**N86-15301*#** Washington Univ., St. Louis, Mo. Dept. of Mechanical Engineering.
**COUPLED ROTOR-BODY VIBRATIONS WITH INPLANE DEGREES OF FREEDOM**
H. MING-SHENG and D. A. PETERS *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 325-341 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

In an effort to understand the vibration mechanisms of helicopters, the following basic studies are considered. A coupled rotor-fuselage vibration analysis including inplane degrees of freedom of both rotor and airframe is performed by matching of rotor and fuselage impedances at the hub. A rigid blade model including hub motion is used to set up the rotor flaplag equations. For the airframe, 9 degrees of freedom and hub offsets are used. The equations are solved by harmonic balance. For a 4-bladed rotor, the coupled responses and hub loads are calculated for various parameters in forward flight. The results show that the

addition of inplane degrees of freedom does not significantly affect the vertical vibrations for the cases considered, and that inplane vibrations have similar resonance trends as do flapping vibrations.
Author

**N86-15302*#** United Technologies Research Center, East Hartford, Conn. Aeromechanics Research.

**ANALYSIS OF POTENTIAL HELICOPTER VIBRATION REDUCTION CONCEPTS**

A. J. LANDGREBE and M. W. DAVIS *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 243-363 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

Results of analytical investigations to develop, understand, and evaluate potential helicopter vibration reduction concepts are presented in the following areas: identification of the fundamental sources of vibratory loads, blade design for low vibration, application of design optimization techniques, active higher harmonic control, blade appended aeromechanical devices, and the prediction of vibratory airloads. Primary sources of vibration are identified for a selected four-bladed articulated rotor operating in high speed level flight. The application of analytical design procedures and optimization techniques are shown to have the potential for establishing reduced vibration blade designs through variations in blade mass and stiffness distributions, and chordwise center-of-gravity location.
B.W.

**N86-15303*#** Sikorsky Aircraft, Stratford, Conn.

**ADAPTATION OF A MODERN MEDIUM HELICOPTER (SIKORSKY S-76) TO HIGHER HARMONIC CONTROL**

J. J. OLEARY, S. B. R. KOTTAPALLI, and M. W. DAVIS *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 365-378 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 01C

Sikorsky Aircraft has performed analytical studies, design analyses, and risk reduction tests have been performed for Higher Harmonic Control (HHC) on the S-76. The S-76 is an 8 to 10,000 lb helicopter which cruises at 145 kts. Flight test hardware has been assembled, main servo frequency response tested and upgraded, aircraft control system shake tested and verified, open loop controllers designed and fabricated, closed loop controllers defined and evaluated, and rotors turning ground and flight tests planned for the near future. Open loop analysis shows that about 2 deg of higher harmonic feathering at the blade 75% radius will be required to eliminate 4P vibration in the cockpit.
B.W.

**N86-15318#** Advanced Engineering Lab., Salisbury (Australia).

**FLUTTER GENERATOR CONTROL AND FORCE COMPUTER**

R. W. LEVINGE Jul. 1985 60 p
(AEL-0242-TM; AR-004-156) Avail: NTIS HC A04/MF A01

The possibility of flutter induced by a store carried under the wing of an aircraft is investigated. This involves in-flight dynamic analysis of structural deformations at given points on an airframe due to forces originating in the store. A system of rotating eccentric masses generates a force spectrum 2.4 to 20.0 Hz in both horizontal and vertical axes. Electronically controlled, the Flutter Generator runs for 28 s with a swept frequency of force is computed continuously and telemetered to ground as an analogue signal.
Author

**N86-15319*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PREDICTION OF WING AEROELASTIC EFFECTS ON AIRCRAFT LIFT AND PITCHING MOMENT CHARACTERISTICS**

C. V. ECKSTROM Nov. 1985 22 p refs Presented at the Aircraft Flight Loads Technology Transfer Conference, Washington, D.C., 16-17 Oct. 1985
(NASA-TM-87631; NAS 1.15:87631) Avail: NTIS HC A02/MF A01 CSCL 01C

The distribution of flight loads on an aircraft structure determines the lift and pitching moment characteristics of the aircraft. When the load distribution changes due to the aeroelastic response of the structure, the lift and pitching moment characteristics also change. Some estimate of the effect of aeroelasticity on stability and control characteristics, particularly lift and pitching moment, is required for use in aircraft simulation models for evaluation of flight characteristics. This presentation outlines a procedure to incorporate aeroelastic effects into lift and pitching moment data from wind tunnel tests. Results are presented which were obtained from applying this procedure to an aircraft with a very flexible transport-type research wing. The procedure described is generally applicable to all types of aircraft.
Author

**N86-15320*#** Information and Control Systems, Inc., Hampton, Va.

**PIFCGT: A PIF AUTOPILOT DESIGN PROGRAM FOR GENERAL AVIATION AIRCRAFT**

J. R. BROUSSARD Dec. 1983 176 p
(Contract NAS1-16303)
(NASA-CR-166123; NAS 1.26:166123; TR-681103) Avail: NTIS HC A09/MF A01 CSCL 01C

This report documents the PIFCGT computer program. In FORTRAN, PIFCGT is a computer design aid for determing Proportional-Integral-Filter (PIF) control laws for aircraft autopilots implemented with a Command Generator Tracker (CGT). The program uses Linear-Quadratic-Regulator synthesis algorithms to determine feedback gains, and includes software to solve the feedforward matrix equation which is useful in determining the command generator tracker feedforward gains. The program accepts aerodynamic stability derivatives and computes the corresponding aerodynamic linear model. The nine autopilot modes that can be designed include four maneuver modes (ROLL SEL, PITCH SEL, HDG SEL, ALT SEL), four final approach models (APR GS, APR LOCI, APR LOCR, APR LOCP), and a BETA HOLD mode. The program has been compiled and executed on a CDC computer.
Author

**N86-15321#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**USE OF HINGED STRAKES FOR LATERAL CONTROL AT HIGH ANGLES OF ATTACK M.S. Thesis**

R. E. ERB May 1985 164 p
(AD-A158005; AFIT/CI/NR-85-61T) Avail: NTIS HC A08/MF A01 CSCL 20D

This thesis investigated the feasibility of using a portion of the leading edge (LE) strake hinged along the longitudinal axis as a roll control device for a high performance aircraft at high angles of attack (AOA). A wind tunnel test was conducted to gather static force and moment data for use in a six degree of freedom computer simulation. Asymmetric strake deflections, both dihedral and anhedral, were investigated. The longitudinal coefficients were little affected by strake deflection, but the lateral directional coefficients showed a nonlinear, but repeatable, behavior with strake deflection. Comparisons to be published data indicate that the strakes produce similar behavior for different aircraft designs. Simulations of the aircraft response to the strakes showed that an improvement over current roll performance could be obtained by combining the positive strake deflection with the ailerons up to 38 deg. AOA, after which the strakes alone produced the best roll performance. Sideslip and AOA must be closely controlled or the aircraft will either not roll, or will depart during the roll. The roll performance using hinged strakes at high AOA is compared to roll performance using differential (LE) flaps. The diffential LE flaps produce comparable roll rates with less sideslip than produced by the hinged strakes. However, the possibility exists of combining hinged strakes with differential (LE) flaps for improved roll performance.
GRA

**N86-15322#** Southwest Research Inst., San Antonio, Tex.
**DIGITAL SERVOCONTROLLER SYSTEM. VOLUME 2. MAINTENANCE MANUAL Final Report, 6 Jul. 1983 - 6 Nov. 1984**
J. LOPEZ and K. MILLER Feb. 1985 70 p
(Contract F33615-83-C-3201)
(AD-A159066; SWRI-14-7676-060-VOL-2;
AFWAL-TR-84-3117-VOL-2) Avail: NTIS HC A04/MF A01
CSCL 09B

This final report describes an exploratory development effort for the design and fabrication of a digital servocontroller system for load control in full-scale air-frame fatigue tests. Each digital controller replaces four analog controllers. The LSI-11/23 microcomputer in the digital controller executes a PI algorithm to implement direct digital control. It may operate in a stand-alone mode or as a slave processor to a master computer via fiber optic link. Other programmable features specifying loop parameters, building load profiles, adjusting control system gains and monitoring alarm and abort conditions. GRA

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-16853**
**APPLICATION OF MECHANICS TO FLIGHT-SIMULATOR PROBLEMS [APLIKACE MECHANIKY V PROBLEMATICE LETOVYCH SIMULATORU]**
K. JANSA Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1985, p. 25-29. In Czech.

The concepts of aircraft flight simulation and of the flight simulator are briefly explained. The main components of a simulator are described, and the current state of flight-simulation technology in Czechoslovakia is reviewed. The functions and operating principles of the main components and systems of flight simulators are described, and the application of mechanics to the solution of problems associated with their development is discussed. B.J.

**A86-16854**
**THE PAST, THE PRESENT, AND THE FUTURE OF AIRCRAFT TEST AND DIAGNOSTIC TECHNOLOGY [MINULOST, SOUCASNOST A BUDOUCNOST KONTROLY A DIAGNOSTIKY LETECKE TECHNIKY]**
J. KOZAK Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1985, p. 71-76. In Czech.

Users' experience with the first-generation test and diagnostic system KL-39 is briefly reviewed. The current status of a second-generation test and diagnostic system is then discussed, with particular attention given to improvements over the original system. Finally, possible future trends in the development of onboard recording and data processing systems are examined. V.L.

**A86-17037**
**A REVIEW OF ADAPTIVE WALL WIND TUNNELS**
U. GANZER (Berlin, Technische Universitaet, West Germany) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 22, no. 2, 1985, p. 81-111. refs

A brief outline is given of the adaptive wall concept. This is followed by a detailed description of the research facilities used to explore the concept. For tests of aerofoils, facilities with two adaptive walls are shown to yield results of very high quality. Wall adaptation was achieved even for fairly high subsonic Mach numbers. For tests of three-dimensional models, first results give hope that for subsonic flow the use of only two adaptive walls may be sufficient to reduce the wall interference to an acceptable level. On the other hand, test sections with three-dimensional adaptive walls have been employed successfully at subsonic main stream condition. Experimental results for low supersonic speeds are not yet available. From theoretical considerations, however, it can be expected that with three-dimensional adaptive walls one can achieve acceptably small wall interferences at low supersonic speeds. Author

**A86-18412*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**HOVERING MODEL HELICOPTER ROTOR TESTING**
R. A. PIZIALI and F. F. FELKER, III (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 7 p.

A relatively large test chamber, chosen to minimize room interference effects during helicopter hovering rotor tests, was found in initial operations to exhibit large, random variations of thrust, torque, and blade flapping. The source of these problems, unsteady recirculation of test chamber flow, was addressed by the addition of a 'flow straightener' that reduced these parameter variations to 1.5 percent of mean values. Rotor performance was then measured outside the chamber in calm, free air conditions and compared with chamber results obtained before and after modifications. Attention is given to wake flow visualization conducted in the test chamber, as well as outside. O.C.

**A86-18414*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**MODIFICATION TO THE NASA LANGLEY 4- BY 7-METER TUNNEL FOR IMPROVED ROTORCRAFT AERODYNAMICS AND ACOUSTICS**
Z. T. APPLIN (NASA, Langley Research Center, Hampton, VA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 10 p. refs

Investigations have been conducted with the aim of improving circuit mean flow characteristics and test section turbulence intensity in the NASA Langley 4 x 7-m wind tunnel. Flow deflectors were instaled to displace the airstream and provide more symmetrical velocity distributions. The periodic flow pulsations of the open test section configuration were addressed by modifications of either the test section entrance, using triangular vanes, or the test section exit, using an alternative flow collector geometry; the latter proved more effective. O.C.

**A86-18429**
**THE WIND TUNNEL AS A DESIGN TOOL**
D. BEVAN and E. J. PYNE (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Wind tunnels intended for use as rotorcraft design tools are noted, in view of a major helicopter manufacturer's experience, to require aircraft models that are sufficiently large for the incorporation of Mach-scaled and instrumented rotor blades, as well as a test section sufficiently wide to accept such rotors. Large power supplies and small electric, hydraulic and pneumatic power systems must be used for main rotor and tail rotor drives, control system actuation, drivetrain lubrication, and cooling. Also required are instrumentation and calibration facilities for the maintenance of models with as many as 100 channels; data acquisition and computation systems should be readily modifiable. O.C.

**A86-18439**

**METHODS OF FULL SCALE FATIGUE TESTING THE APACHE HELICOPTER ROTOR SYSTEMS**

G. J. KORKOSZ (Hughes Helicopters, Inc., Technology Dept., Culver City, CA) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 9-1 to 9-20.

Attention is given to the test methods and fixturing appratus that were developed for full scale fatigue tests of the YAH-64 military helicopter main rotor system's retention characteristics and root-end fatigue, as well as the tail rotor blade/hub assembly's fatigue. The selection of mechanical (electrohydraulic and pneumatic) loading and reacting components for these tests is discussed. Test parameters encompassed tension, torsion, coning, feathering, flapping, flapwise bending, feathering moment, lead-lag load, and chordwise shear. O.C.

**A86-18440**

**A RIG FOR THE FATIGUE TESTING OF ROTOR HUBS**

G. GRANGER, JR. and R. MAYERJAK (Kaman Aerospace Corp., Bloomfield, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 11-1 to 11-15.
(Contract N00019-82-G-0107)

A rig is described for the fatigue testing of a full-scale main rotor hub. The load paths within the rig are compact, direct, and self-reacting. As a consequence, the rig is small and portable. Its main framework is an open pyramid that is constructed of welded steel plates and rolled sections. The rig is capable of applying significant loads. In current tests of a full-scale rotor hub, the loadings include: centrifugal force = 102,000 lbs; torque = 426,000 inch-lbs; lift = 16,100 lbs; and hub moment = + or - 265,000 inch-lbs. The loads are generated by hydraulic cylinders. The equipment for controlling, measuring, and recording loads is described. In general, such equipment is not dedicated solely to hub testing, but rather is transferable to other projects when not in use for hub testing. It is concluded that the new rig offers a practical, inexpensive method for the fatigue testing of full-scale rotor hubs. Author

**A86-18441**

**FATIGUE TEST OF THE APACHE AH-64 AIRFRAME**

G. D. DEVEAUX and A. W. MAGULA (Hughes Helicopters, Inc., Culver City, CA) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 12-1 to 12-26.

A fatigue test program of the AH-64 Apache Static Test Airframe is described. In place of the complete airframe being subjected to a spectrum of flight maneuver test conditions, a series of component airframe tests were performed. S-N and spectrum fatigue test data were obtained on selected airframe components, the airframe structure adjacent to these components, and the attachments joining the components to the structure. This series of airframe component tests demonstrated compliance with acceptance limits of acquiring sufficient S-N data to define S-N curves and block spectrum testing to substantiate design fatigue life capability. Of noteworthy interest is that prior to this test program, this airframe was subjected to static limit and ultimate flight and landing load conditions. Author

**A86-18453**

**WIDE-ANGLE, LOW-ALTITUDE FLIGHT SIMULATOR VISION SYSTEM FOR COCKPIT RESEARCH AND AIRCREW TRAINING**

A. CORT and R. HAWTIN (Westland Helicopters, Ltd., Yeovil, England) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 13 p.

'Vistasim' is a low altitude flight simulator for training and operational research whose configuration features a flexible transparency that travels continuously in a roll-wound loop. With normal flight planning, flights of several miles can be undertaken before the scene is represented. A laser light source is used that allows flight to altitudes as low as the ground to be simulated. A parallel action linkage and gimbals system is used to move the transparency in pitch and roll. O.C.

**A86-18462**

**ADVANCED TECHNOLOGY COCKPIT SIMULATOR**

A. H. SHAW (Westland Helicopters, Ltd., Yeovil, England) IN: Specialists' Meeting on Advanced Cockpit Design, Grapevine, TX, October 3, 4, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

An advanced technology cockpit simulator has been manufactured and evaluated whose design is oriented toward helicopter manufacturing and operating cost reduction, as well as the introduction of a high degree of commonality into civilian and military derivatives of a given helicopter design. Human factors implications of candidate advanced cockpit technologies were of primary importance during the simulator design stage. Attention is given to the incorporation of a side-arm controllers, direct pilot voice command inputs, control and display panels, and subsystems integration. O.C.

**A86-18722**

**AIRCRAFT COMPARTMENT PREHEATING DEVICE LUVO 100 [LUFTFAHRZEUGKABINENVORWAERMGERAET LUVO 100]**

K. EPPERLEIN (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-Oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 5, 1985, p. 167, 168. In German.

The present article is concerned with a preheating device which has been developed for the airline Interflug. At the airport Berlin-Schoenefeld, the preheating of the aircraft compartments is generally accomplished with the aid of special preheating devices. Advantages of a ground-based climatization procedure are related to lower cost and better environmental conditions. The ground-based preheating devices which are currently employed by Interflug provide heat through the compartment doors and consume much energy. There are also certain restrictions with respect to the employment of these devices. Because of this situation, it became necessary to develop an aircraft compartment preheating device which is free of the considered disadvantages. An important aspect is the possibility of an employment of the preheater in the aircraft types IL-62, Tu-134, and IL-18. The characteristics of the LUVO 100 are discussed together with information regarding its performance. G.R.

**N86-14276*#** Madison Magnetics, Inc., Wis.

**MAGNETIC SUSPENSION AND BALANCE SYSTEM ADVANCED STUDY Final Report, Dec. 1984 - Jun. 1985**

R. W. BOOM, Y. M. EYSSA, G. E. MCINTOSH, and M. K. ABDELSALAM Washington NASA Oct. 1985 122 p refs
(Contract NAS1-17931)
(NASA-CR-3937; NAS 1.26:3937) Avail: NTIS HC A06/MF A01 CSCL 14B

An improved compact design for a superconducting magnetic suspension and balance system for an 8 ft. x 8 ft. transonic wind tunnel is developed. The original design of an MSBS in NASA Cr-3802 utilized 14 external superconductive coils and a superconductive solenoid in the airplane test model suspended in a wind tunnel. The improvements are in the following areas: test model solenoid options, dynamic force limits on the model, magnet cooling options, structure and cryogenic designs, power supply specifications, and cost and performance evaluations. The improvements are: MSBS cost reduction of 28%, weight; reduction of 43%, magnet system ampere-meter reduction of 38%, helium liquifier capacity reduction by 33%, magnet system stored energy reduction by 55%, AC loss to liquid helium reduced by 76%, system power supply reduced by 68%, test coil pole strength increased by 19%, wing magnetization increased by 40%, and control frequency limit increased by 200% from 10 Hz to 30 Hz. The improvements are due to: magnetic holmium coil forms in the test model, better rare earth permanent magnets in the wings, fiberglass-epoxy structure replacing stainless steel, better coil configuration, and new saddle roll coil design. Author

**N86-14279#** Air Force Human Resources Lab., Brooks AFB, Tex.
**ADVANCED SIMULATOR FOR PILOT TRAINING: EFFECTS OF COLLIMATION ON ACCOMMODATION AND VERGENCE Interim Technical Paper, Oct. 1983 - Jun. 1984**
H. H. BELL and K. J. CIUFFREDA Sep. 1985 13 p
(Contract AF PROJ. 112-3)
(AD-A159545; AFHRL-TP-85-27) Avail: NTIS HC A02/MF A01
CSCL 06P

Accommodation and binocular vergence were measured using a haploscope optometer for 10 observers who viewed collimated (0.15 diopter) and noncollimated presentations of a simulated approach and landing. Collimated imagery produced a small but consistent decrease in accommodation for each observer (M = 12.7 meters). Collimation also produced an increase in the perceived size of objects within the visual scene. These results suggest that the primary influence of collimation is on binocular vergence and that differences in the perceived quality of collimated and noncollimated simulator displays are due to differences in binocular vergence rather than in accommodation. GRA

**N86-14449#** Joint Publications Research Service, Arlington, Va.
**CONFIGURATION AND LONGITUDINAL WIND TUNNEL TESTING]HY] OF FORWARD-SWEPT WINGS**
W. YE and R. XIAO *In its* China Report: Science and Technology (JPRS-CST-85-036) p 80-90 23 Oct. 1985 refs Transl. into ENGLISH from Kongqidonglixue Xuebao (Mianyang, China), no. 2, Jun. 1985 p 61-68
Avail: NTIS HC A07/MF A01

Based on low-speed wind tunnel testing, calculation of load distribution and the transonic-supersonic area rule, the aerodynamic characteristics of aircraft with a configuration of forward-swept wings (FSW) are analyzed. Measures for improving the aerodynamic characteristics of FSW are suggested. The principle of symmetry is used to solve problems related to the application of the area eddy method and the area rule calculation method for FSW. The experimental research and calculations show that FSW have rather good aerodynamic characteristics and that a winglet at the wing tip can improve the lift and lift-drag ratios FSW. FSW more closely approximate an optimum load distribution than do aft-swept wings (ASW). There are obvious improvements in airflow separation at the FSW base from using a close-coupled canard and a fairing panel at the wing base. FSW more closely approximate an optimum load distribution than do ASW. The axial cross-sectional load distribution on an FSW with a canard more easily approximates an optimum load distribution and thereby can result in an obvious reduction in zero-lift wave drag. Author

**N86-15323*#** Kansas Univ. Center for Research, Inc., Lawrence.
**AN ANALYSIS OF CROSS-COUPLING OF A MULTICOMPONENT JET ENGINE TEST STAND USING FINITE ELEMENT MODELING TECHNIQUES Final Report**
W. G. SCHWEIKHARD and W. N. SINGNOI 1985 55 p refs
(Contract NAG3-85)
(NASA-CR-176424; NAS 1.26:176424) Avail: NTIS HC A04/MF A01 CSCL 14B

A two axis thrust measuring system was analyzed by using a finite a element computer program to determine the sensitivities of the thrust vectoring nozzle system to misalignment of the load cells and applied loads, and the stiffness of the structural members. Three models were evaluated: (1) the basic measuring element and its internal calibration load cells; (2) the basic measuring element and its external load calibration equipment; and (3) the basic measuring element, external calibration load frame and the altitude facility support structure. Alignment of calibration loads was the greatest source of error for multiaxis thrust measuring systems. Uniform increases or decreases in stiffness of the members, which might be caused by the selection of the materials, have little effect on the accuracy of the measurements. It is found that the POLO-FINITE program is a viable tool for designing and analyzing multiaxis thrust measurement systems. The response of the test stand to step inputs that might be encountered with thrust vectoring tests was determined. The dynamic analysis show a potential problem for measuring the dynamic response characteristics of thrust vectoring systems because of the inherently light damping of the test stand. E.A.K.

**N86-15324#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
**CONCEPTS FOR THE DEVELOPMENT OF A NONDESTRUCTIVE TESTING AND EVALUATION SYSTEM FOR RIGID AIRFIELD PAVEMENTS Ph.D. Thesis**
P. T. FOXWORTHY 1985 274 p
(AD-A158004; AFIT/CI/NR-85-93T) Avail: NTIS HC A12/MF A01 CSCL 13B

This thesis develops a complete system for nondestructive testing and evaluation of rigid airfield pavements. An extensive review of present destructive and nondestructive equipment and methodologies is made to form the basis for selection of the equipment and analytical model used in this research. A brief description of the selected Dynatest Model 8000 Falling Weight Deflectometer and the ILLISLAB finite element computer model is presented. Three Air Force installations were chosen for in-depth study of pavement response to FWD loads under a variety of environmental and geological conditions. Techniques are presented to determine the location of maximum damage to rigid pavement slabs for one or any combination of aircraft, and the validity of the calculated stresses is established through comparisons of measured and predicted deflections at joints. Major study findings include: (1) new designations for pavement features based on actual loading conditions, (2) guidelines for planning and conducting large scale evaluations of major airfield systems, (3) a computer-based determination of E and K, (4) joint behavior prediction under fluctuating temperatures and their effect on generated slab stresses, (5) procedures to account for the annual distribution of traffic over the range of temperatures normally experienced at any facility, (6) a simplistic means of estimating total past damage from aircraft operations, and (7) development of computer programs to predict remaining structural life of rigid airfield pavements. GRA

**N86-15328#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
**PROGRAMMING A MULTIPLE-ORIFICE HYDRAULIC DECELERATOR Final Report, Mar. 1978 - Feb. 1985**
C. G. TOLER Jun. 1985 30 p
(Contract AF PROJ. 7231)
(AD-A159428; AAMRL-TR-85-049) Avail: NTIS HC A03/MF A01 CSCL 14B

The AAMRL Horizontal Deceleration Facility is used to conduct experimental research for the development of design criteria for aircrew personnel protection. The hydraulic deceleration device is a water-filled cylinder. A piston mounted on the front of a deceleration sled ruptures a frangible diaphragm positioned at the opening of the cylinder and displaces the water in the cylinder through the multiple orifices. As the piston travels along the cylinder it closes off the orifices thereby decreasing the available area for the water to escape. Bernoulli's conservation-of-energy equation was applied to the physical state of fluid flow in the cylinder, allowing the orifice area to be determined as a function of the piston cross-sectional area, acceleration, velocity and weight of the sled. A computer program was developed to determine the appropriate plug orifice and location to produce desired acceleration-time profiles. The program corrects for the energy loss due to the vena contracta of each plug. Data from several tests were used to determine a correction coefficient for other losses, such as those attributable to conduit length and surface roughness, as a lumped quantity. Author (GRA)

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## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-18355**

**STABILITY OF LARGE DAMPED FLEXIBLE SPACECRAFT WITH STORED ANGULAR MOMENTUM**

P. K. MAHARANA and S. K. SHRIVASTAVA (Indian Institute of Science, Bangalore, India) Acta Astronautica (ISSN 0094-5765), vol. 12, Nov. 1985, p. 889-898. refs

The vibrational stability of large flexible structurally damped spacecraft carrying angular momentum and undergoing large rigid body rotations is studied theoretically. Analytical solutions to the motion of rigid gyrostats under torque free conditions are developed which serve as a generalization of existing solutions. Differential equations having constant or periodic coefficients for the structural vibration of the spacecraft, are obtained and Floquet theory is applied to determine the stability of the periodic differential equations. Analysis of a few beam-like and plate-like configurations indicate that the introduction of a single reaction wheel into an axisymmetric satellite does not alter the stability criterion. However, introduction of constant speed rotors deteriorates vibrational stability. I.H.

**N86-14282#** Army Armament Research and Development Command, Dover, N. J. Large Caliber Weapon Systems Lab.

**AN ANALYTICAL MODULARIZED TREATMENT OF AUTOPILOTS FOR GUIDED PROJECTILE SIMULATIONS**

E. M. FRIEDMAN and M. J. AMORUSO Aug. 1985 42 p (AD-A159311; AD-E401390; ARLCD-TR-85025; Avail: NTIS HC A03/MF A01 CSCL 19A

An innovative technique was developed by which piecewise analytical solutions to guidance and control transfer functions were obtained for use in larger but lower frequency computer simulations of guided munitions. Numerical integration, which is typically used to treat such transfer functions, significantly reduces the integration time step, and increases computer execution time for the overall simulation. The modularized analytical approach accommodates integration time steps associated with the lower frequencies of airframe dynamics which results in faster simulation execution and considerable savings in cost and execution time. GRA

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## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-16201**

**CARBON FIBRES: USES AND PROSPECTS; PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE, LONDON, ENGLAND, OCTOBER 8-10, 1985**

Conference sponsored by the Plastics and Rubber Institute. London, Plastics and Rubber Institute, 1985, 189 p. For individual items see A86-16202 to A86-16209.

Among the topics discussed are manufacturing advancements toward higher strain carbon fibers, the comparative performance of commercially available carbon fibers, woven carbon fiber-reinforced plastic (CFRP) fabrics, the use of carbon fiber-based papers as a sheet reinforcement material, metal-coated carbon fibers for conductive composites, and the development prospects for carbon fiber-reinforced molding compounds and thermoplastics. Also covered are major CFRP civil aircraft components, CFRP helicopter structures, matrix systems for high performance airframe structures, CFRP parts integration advantages and problems, carbon fiber-reinforced coil springs, composite materials in racing car design, carbon fiber reinforcement applications in sports equipment and marine systems, and CFRP medical prosthesis development. A final section is devoted to carbon/carbon composite developments and hybrid fiber-reinforced composite systems. O.C.

**A86-16203**

**MANUFACTURING ADVANCE TOWARDS HIGH STRAIN FIBERS**

Y. IZUKA, T. NORITA, T. NISHIMURA (Toray Industries Inc., Tokyo, Japan), and K. FUJISAWA (Toray Europe, Ltd., London, England) IN: Carbon fibres: Uses and prospects; Proceedings of the Third International Conference, London, England, October 8-10, 1985 . London, Plastics and Rubber Institute, 1985, p. 2/1-2/15. refs

In order to fulfill aircraft primary structure composite requirements, such high strength/modulus carbon fibers as T800 and T400 have been developed. Composites employing the former yield 20 percent higher tensile and compressive modulus, and 60-80 percent higher tensile strength, than T300 fiber-based composites. Penetration impact loads are, moreover, doubled. The compressive and transverse tensile strengths of the T800-reinforced composite do not, however, reflect the improvement of fiber properties. O.C.

**A86-16208**

**INTERLEAF TECHNOLOGY FOR CARBON COMPOSITE AIRCRAFT PRIMARY STRUCTURE**

R. B. KRIEGER, JR. (American Cyanamid Co., Teterboro, NJ) IN: Carbon fibres: Uses and prospects; Proceedings of the Third International Conference, London, England, October 8-10, 1985 . London, Plastics and Rubber Institute, 1985, p. 23/1-23/12.

Carbon fiber composites can save weight over aluminum in aircraft structure. This savings could be magnified if the composite were 'tougher', i.e., more tolerant of damage and stress concentration. To accomplish this, the Interleaf Concept has been developed. A thin, high elongation, resin interleaf is placed between each fiber ply to provide toughness. Each ply has its fibers in an epoxy matrix for high hot-wet performance. The two resins remain discrete during cure and so interleaf toughness does not compromise matrix hot-wet compression strength. Author

**A86-16234**

**DYNAMIC THERMAL ANALYSIS CHARACTERIZATIONS OF ELECTRON-BEAM CURED ADHESIVES**

F. J. CAMPBELL (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: Adhesive chemistry: Developments and trends . New York, Plenum Press, 1984, p. 379-391. Navy-supported research. refs

Continuous scans of modulus versus temperature utilizing the DuPont Dynamic Mechanical Analyzer (DMA) has provided a comparison of the high temperature service capabilities of radiation-cured experimental formulations of a vinyl-modified epoxy resin, Shell Epocryl-12. These scans were compared to data obtained when the same materials were applied as adhesives on aluminum test panels, radiation-cured with an electron beam, and lap shear strength tested at discrete temperatures. The DMA instrument utilizes a thin rectangular specimen for the analysis, so specimens can be cut from blocks or from flat sheets. In this case the sepcimens were cured as sheets of resin-saturated graphite-fibers. The same order of high temperature stability was obtained by each method. However, the DMA method provided a more complete chracterization of temperature performance in a much shorter test time and thus, it can be very useful for quick analyses of formulation and processing variables in many types of materials optimization studies. The paper will present details of this study with illustrations of the comparisons. Author

**A86-16278**

### THERMAL BARRIER COATINGS FOR JET ENGINE IMPROVEMENT

G. JOHNER and K. K. SCHWEITZER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Metallurgical coatings 1984; Proceedings of the Eleventh International Conference, San Diego, CA, April 9-13, 1984. Volume 2 . Lausanne, Switzerland, Elsevier Sequoia, S.A., 1984, p. 301-315. refs

The aim of these investigations is to develop thermal barrier coatings (TBCs) with improved resistance against thermal cycling to prevent problems of over-heating in the hot section of jet engines. Plasma-sprayed TBCs consisting of an Ni-Cr-Al bond coat and zirconia overlayer stabilized with different materials (CaO, MgO or Y2O3) were tested in a burner rig under thermocyclic conditions, in a hot gas centrifugal rig and in a modern jet engine. These tests demonstrate good correlation between the failure mode of the coatings in the thermocyclic tests and in engine tests. The best performance in all tests was shown by zirconia partially stabilized with yttria according to microanalytical investigations of the unstresed and stressed TBCs. Furthermore, heat treatments as well as ongoing optimization of the spraying parameters of the TBCs demonstrate potential improvement. Author

**A86-16750**

### THE TEMPERATURE DEPENDENCE OF THE ELECTRICAL CONDUCTIVITY OF JET FUELS WITH ANTISTATIC ADDITIVES [ZAVISIMOST' ELEKTROPROVODIMOSTI REAKTIVNYKH TOPLIV S ANTISTATICHESKIMI PRISADKAMI OT TEMPERATURY]

A. I. BELOUSOV and E. M. BUSHUEVA (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Neftianoi Promyshlennost', Moscow, USSR) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 10, 1985, p. 26-28. In Russian. refs

A study is made of the temperature dependence of the electrical conductivity of jet fuels with Soviet-made (Sigbal and ASP-1) and foreign (ASA-3 and Kerostat) antistatic additives. An analysis of the results obtained shows that the change of the electrical conductivity of such fuels with temperature is largely determined by the additive. The smallest change of electrical conductivity (1.3 percent per 1 C) is observed for fuels containing the antistatic additive Sigbol. V.L.

**A86-16866**

### STRUCTURAL MATERIALS IN AERONAUTICS - PROSPECTS AND PERSPECTIVES

G. G. POPE (Royal Aircraft Establishment, Farnborough, England) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, Sept.-Oct. 1985, p. 269-283. refs

Recent developments in materials and their prospects for application in airframes and engines are reviewed, with particular attention paid to advances in the U.K. Some of the more important considerations that arise when selecting material for use in airframes and aeroengines are summarized. The merits of composites, titanium alloys, steels, aluminum alloys, and gas turbine materials are discussed in detail. It is concluded that new materials will be acceptable only if a clear understanding is achieved of the relationship between composition, microstructure and material behavior, the manufacturing route, and the quality control of the product. C.D.

**A86-17499**

### ROLE OF DISPERSED OXIDES IN REDUCING SUBSTRATE/COATING INTERDIFFUSION

K. L. LUTHRA (General Electric Co., Schenectady, NY) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 3, Nov.-Dec. 1985, p. 2574-2577. refs

Theoretical calculations have been performed to evaluate the usefulness of dispersed oxides in a barrier layer in reducing substrate/coating interdiffusion. The important variables influencing interdiffusion are (1) the ratio of the thickness of the barrier layer to the total coating, (2) the volume fraction of oxides in the barrier layer, and (3) a tortuosity factor that depends on the distribution of oxides in the barrier layer. The results of calculations suggest that it may be possible to increase the operating life by a factor of up to about 2.5 or increase the operating temperature by a maximum of about 75 C in systems where life is limited by substrate/coating interdiffusion. Author

**A86-18432**

### GENERIC ASPECTS OF DELAMINATION IN FATIGUE OF COMPOSITE MATERIALS

T. K. OBRIEN (U.S. Army Structures Laboratory, Hampton, VA) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 2-1 to 2-5. refs

A review of recent work characterizing composite delamination failure in fatigue is presented. Results from tensile fatigue tests on unnotched laminates are high-lighted to demonstrate the influence of delamination on stiffness, strength, and life. The use of fracture mechanics to achieve a generic characterization of delamination is demonstrated. A fatigue design philosophy is proposed based on an understanding of composite delamination behavior. Author

**A86-18434**

### INTERPRETATION AND EVALUATION OF FATIGUE PROPERTIES OF CAST, HIP AND HEAT TREATED TITANIUM UH-60A M. R. HUB

C. MATUSOVICH and M. M. SCHWARTZ (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 4-1 to 4-22.
(Contract DAAO46-79-C-0043)

Attention is given to the methodology and results of the third phase of a U.S. Army program evaluating the static, fatigue and fracture toughness properties of rammed graphite-cast Ti-6Al-4V material for helicopter main rotor hubs that are subsequently HIPped and beta-STOA processed. Ultimate tensile and yield strengths, elongation, area reduction, and S-N curve shapes were obtained. The typical mean fatigue strength of the cast material was comparable to that of conventionally forged beta-STOA production hubs' material; a higher degree of scatter in the castings-derived data than in that for forgings is, however, noted and discussed. O.C.

**A86-18437**

### FULL SCLE FATIGUE TESTING OF ADVANCED FIBER COMPOSITE COMPONENTS

D. O. ADAMS and H. L. KEARNEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 7-1 to 7-15.

The importance of full-scale testing in the development process for fiber-reinforced composite helicopter dynamic components is discussed, and illustrated by means of several examples drawn from Sikorsky experience in the use of composites in a wide variety of structural applications. Laboratory fatigue testing is conducted at Sikorsky on all flight-critical dynamic components in order to determine structural adequacy. The intention of this testing is to generate fracture modes by testing with loads accelerated above the levels encountered in service. The fracture mechanisms exposed to date in this testing on composite components have not been fiber-related, but rather matrix-related (interlaminar shear or disbond). These fracture mechanisms are related to design details such as ply endings, holes, curved sections, bonded joints, or bolted joints. Test methods and fracture mechanisms for the following components are discussed: Cross Beam Tail Rotor Spars, Main Rotor Blades, UH-60A External Stores Support and S-76 stabilizer. Structural analysis of these components and fracture modes is not presented since the primary mechanism - interlaminar shear is difficult to treat analytically. This emphasizes the importance of the empirical approach as a necessary complement to analysis in the development of critical composite components used in fatigue loaded applications. Author

**N86-14314*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FAILURE MECHANISMS OF LAMINATES TRANSVERSELY LOADED BY BOLT PUSH-THROUGH**

W. A. WATERS, JR. (Kentron International Inc., Hampton, Va.) and J. G. WILLIAMS Sep. 1985 26 p refs
(NASA-TM-87603; NAS 1.15:87603) Avail: NTIS HC A03/MF A01 CSCL 11D

Stiffened composite panels proposed for fuselage and wing design utilize a variety of stiffener-to-skin attachment concepts including mechanical fasteners. The attachment concept is an important factor influencing the panel's strength and can govern its performance following local damage. Mechanical fasteners can be an effective method for preventing stiffener-skin separation. One potential failure mode for bolted panels occurs when the bolts pull through the stiffener attachment flange or skin. The resulting loss of support by the skin to the stiffener and by the stiffener to the skin can result in local buckling and subsequent panel collapse. The characteristic failure modes associated with bolt push-through failure are described and the results of a parametric study of the effects that different material systems, boundary conditions, and laminates have on the forces and displacements required to cause damage and bolt pushthrough failure are presented. Author

**N86-14317*#** Lockheed-California Co., Burbank.

**FLIGHT SERVICE EVALUATION OF ADVANCED COMPOSITE AILERONS ON THE L-1011 TRANSPORT AIRCRAFT Annual Flight Service Report, Jul. 1984 - Jun. 1985**

R. H. STONE Jul. 1985 10 p refs
(Contract NAS1-15069)
(NASA-CR-177960; NAS 1.26:177960; LR-30904; AFSR-3)
Avail: NTIS HC A02/MF A01 CSCL 11D

Flight service evaluation of composite inboard ailerons on the L-1011 under Contract NAS 1-15069 for a period of five years is discussed. The period from July 1984, when the second yearly inspections were completed, through June 1985 is covered. Four shipsets of graphite/epoxy composite inboard ailerons were installed on L-1011 aircraft for this maintenance evaluation program. These include two Delta aircraft and two TWA aircraft. A fifth shipset of composite ailerons were installed in 1980 on Lockheed's flight test L-1011. This aircraft is now inactive and inspections were therefore not performed this year. No visible damage was observed on any of the composite ailerons, and no maintenance action has occurred on any of the composite parts except for repainting of areas with paint loss. Flight hours on the airline components at the time of inspection ranged from 8767 to 10,804 hours, after approximately 3 years of service. Author

**N86-14391#** Brookhaven National Lab., Upton, N. Y.

**FURFURYL ALCOHOL POLYMER CONCRETES FOR USE IN ALL-WEATHER REPAIRS OF CONCRETE AND ASPHALT SURFACES**

L. E. KUKACKA and T. SUGAMA Apr. 1985 26 p Presented at the American Concrete Institute Fall Meeting on Polymers in Concrete, Chicago, Illinois, 3 Oct. 1985
(Contract DE-AC02-76CH-00016)
(DE85-014825; BNL-36465; CONF-851[illegible]115-1) Avail: NTIS HC A03/MF A01

The following criteria were established: high strength at an age of 1 h, placement of the materials must be possible during heavy precipitation over temperatures ranging from -32 to 52 C, and the chemical constituents should be low cost and have long-term stability when contained in a maximum of three packages during storage. A formulation consisting of furfuryl alcohol monomer (FA), (ALPHA), (ALPHA), (ALPHA) - trichlorotoluene, pyridine, silane, zinc chloride, silica filler, and coarse aggregate meets these requirements. Optimized formulations were established for use with premixed and percolation placement methods. The premixed formulation is compatible with moisture contents up to 4% by weight of the total mass, which simulates placement in a 2.54 cm/h rainfall. The working time for the FA-PC slurry can be controlled at greater than or equal to 15 min over the entire operating temperature range by simply varying the (ALPHA), (ALPHA), (ALPHA)-trichlorotoluene catalyst concentration while holding all of the other constituents constant. Prototype equipment for the mixing and placement of FA-PC was demonstrated: a concrete transit mix supply of mixed aggregate, a hopper-fed volumetric feed screw which supplied aggregate at a known rate to a mixing screw, and a monomer pump and spray nozzle. DOE

**N86-14402#** Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

**DEVELOPMENT OF NEW COMBUSTOR TECHNOLOGIES FOR APPLICATION TO ALTERNATIVE AEROENGINE FUELS, PHASE 1 Final Report, Dec. 1983**

B. SIMON Bonn Bundesministerium fuer Forschung und Technologie Jun. 1985 95 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-85-004; ISSN-0170-1339) Avail: NTIS HC A05/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 20

An air blast fuel injection system for alternative fuels was developed and tested in a reversed flow annular combustion chamber. It was adapted to the boundary conditions of the jet engine (size, form, thermodynamical data). A wall temperature computational program was developed taking into account the impact of the various fuels on the wall temperatures. Recommendations are made for further investigation of an optimal chamber, the introduction of improved cooling techniques, the influence of fuels on the chamber and the application of the air blast injector with alternative flame tube shapes. Author (ESA)

**N86-15346#** Joint Publications Research Service, Arlington, Va.

**EFFECTS OF VIBRATION-INDUCED CAVITATION OF PHYSICOCHEMICAL CHARACTERISTICS OF AIRCRAFT FUEL**

P. P. MERTSALOV, B. G. BEDRIK, and K. L. SUPONKO *In its* USSR Report: Chemistry (JPRS-UCH-85-013) p 46-47 22 Oct. 1985 Transl. into ENGLISH from Khimiya i Tekhnologiya Topliv i Masel (Moscow, USSR), no. 7, Jul. 1985 p 23-25
Avail: NTIS HC A04/MF A01

An analysis was conducted on the factors leading to vibration-induced cavitation in aircraft fuel, resulting from sudden changes in hydrostatic pressure and resultant variability in tensile stresses. The data demonstrates that both hydrodynamic and aircraft factors are predisposed to maximum cavitation in the vibration range of 30 to 300 Hz and vibroacceleration of 10 to 30 g. The specific alterations in fuels TS-1 and T-6 consist of changes in the granulometric profile with an increase in the percentage of particles 1 to 5 micron in size and a decrease in the percentages of those in the 5 to 100 micron (most pronounced with the 15 to 100 micron fraction). Other changes include a decrease in fuel viscosity and thermal stability, and an increase in tar substances. Vibration is, therefore, an important factor to be considered in the formulation and testing of new aviation fuels. Author

**N86-15350*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**STRESS CONCENTRATION AROUND A SMALL CIRCULAR HOLE IN THE HIMAT COMPOSITE PLATE**

W. L. KO Dec. 1985 18 p refs
(NASA-TM-86038; H-1235; NAS 1.15:86038) Avail: NTIS HC A02/MF A01 CSCL 11D

Anisotropic plate theory is used to calculate the anisotropic stress concentration factors for a composite plate (AS/3501-5 graphite/epoxy composite, single ply or laminated) containing a circular hole. This composite material is used on the highly maneuverable aircraft technology (HiMAT) vehicle. It is found that the anisotropic stress concentration factor could be greater or less than 3 (the stress concentration factor for isotropic materials), and that the locations of the maximum tangential stress points could shift with the change of fiber orientation with respect to the loading axis. The effect of hole size on the stress concentration factor is examined using the Point Stress Criterion and the Averaged Stress Criterion. The predicted stress concentration factors based on the two theories compared fairly well with the measured values for the hole size 0.3175 cm (1/8 in). It is also found that through the lamination process, the stress concentration factor could be reduced drastically, indicating an improvement in structural performance. Author

**N86-15412*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ANTIMISTING KEROSENE: DEVELOPMENT OF A CONTINUOUS 10 GPM IN-LINE BLENDER Final Report, Aug. 1983 - Sep. 1984**

P. PARIKH, A. YAVROUIAN, and V. SAROHIA Oct. 1985 29 p refs

(Contract NAS7-918; DTFA03-80-A-00215)

(NASA-CR-176432; JPL-PUB-D-2582; NAS 1.26:176432; FAA/CT-85/12) Avail: NTIS HC A03/MF A01 CSCL 07D

A continuous inline blender is developed at JPL to blend precisely metered quantities of ICI developed polymer slurries into a stream of Jet-A fuel. The inline blender is used to produce 5 to 10 gallons per minute of freshly blended AMK. The proprietary ICI slurries are made of FM-9 type polymers in a glycol/amine carrier fluid. Depending upon the polymer particle size and powder loading, the slurry consistency ranges from free flowing to a paste with viscosities in the range of 5000 to 100,000 centipoise. With one of the polymer slurries, a provision is made for a time delay between the addition of slurry and the addition of the amine sequentially into the Jet-A stream. Author

**N86-15415#** Monsanto Co., Dayton, Ohio.

**VARIABILITY OF MAJOR ORGANIC COMPONENTS IN AIRCRAFT FUELS Final Report, Nov. 1983 - Dec. 1984**

B. MASON, K. WIEFLING, and G. ADAMS Aug. 1985 216 p

(Contract F08635-83-C-0067)

(AD-A159057; AFESC/ESL-TR-85-13) Avail: NTIS HC A10/MF A01 CSCL 21D

This report summarizes qualitative data on the chemical variability of approximately 300 features (chemical components or mixture of components) in neat Air Force distillate fuels, in water equilibrated with the fuels, and in the vapor phase above the fuels, from over 50 fuel sources. These data were obtained to better understand the environmental effects of possible fuel spills and to serve as baseline data which can be used in the development of environmental models for photochemical smog, soot formation from Air Force use of these fuels. Over 50 petroleum-derived JP-4 fuels, one shale-derived JP-4 fuel, and one petroleum-derived JP-5 fuel were analyzed. This report summarizes results for the variability of the major features in water which has been equilibrated with the neat fuels, and in the headspace above the neat fuels. Data base management programs were used to measure feature variability in the data base of over 50 fuels. Feature concentration averages, ranges, standard deviations, and percent relative standard deviations were determined for the 300 features in over 50 fuels, analyzed in duplicate. The variability of data acquisition and data analysis phases of the study was also assessed by calculating the averages, ranges, standard deviations, and percent relative standard deviations for the 300 feature concentrations of one JP-4 fuel which was used as the Reference Fuel and analyzed 18 times for water-soluble features and seven times for vapor phase features. GRA

**N86-15416#** AeroChem Research Labs., Inc., Princeton, N. J.

**FUEL EFFECTS ON SOOT FORMATION IN TURBOJET ENGINES Final Report, 15 Sep. 1983 - 14 Mar. 1985**

R. J. GILL and D. B. OLSON Aug. 1985 104 p

(Contract N00014-83-C-2311; DA PROJ. Z08-38)

(AD-A159073; AEROCHEM-TP-451) Avail: NTIS HC A06/MF A01 CSCL 21D

The results of tests on how fuel composition affects the performance of three Navy aircraft engine combustors, the TF30, T56, and T53, were analyzed. The objective of this analysis was to identify which fuel property best correlated with the smoke-related measurements: radiation flux, linear temperature rise, smoke number, and smoke emissions. The effects of fuel composition were investigated by using a series of 10 Naval Air Propulsion Center jet fuels with various properties, such as hydrogen contents of 12.83 to 13.82% and total aromatic hydrocarbon contents of 15.9 to 28.5%. Several laboratory combustion characteristics of these fuels were measured and these characteristics were used in analysis. Altogether, 15 fuel parameters were used to correlate the 45 combustor test results. The reported operating conditions of the tests, such as inlet air pressure, inlet air temperature, or fuel/air ratio, were also used as correlating parameters to determine whether variations in these variables, nearly constant for individual tests, also affected the smoke-related test results. GRA

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## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-16248**

**ON THE TEACHING OF THE PRINCIPLES OF WING FLEXURE-TORSION FLUTTER**

G. J. HANCOCK, J. R. WRIGHT (Queen Mary College, London, England), and A. SIMPSON (Bristol, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Oct. 1985, p. 285-305. refs

This note attempts to clarify some basic ideas, and correct some common misunderstandings, on wing flexure-torsion flutter. Topics include: (1) an understanding of the physics of wing flexure-torsion flutter through a number of specific examples; (2) an examination of the energy interpretation of the physics of flutter, indicating its limited usefulness; (3) a discussion of the significant differences between wing flexure-torsion flutter and the Duncan flutter engine; (4) a graphical representation to assess the contribution of various parameter to flutter onset; (5) subcritical response below the critical flutter speed; and (6) some practical wing flutter considerations. Author

**A86-16761**

**THE DYNAMICS OF ELASTIC BARS UNDER CONDITIONS OF ARBITRARY KINEMATIC EXCITATION [DINAMIKA UPRUGIKH STERZHNEI PRI PROIZVOL'NOM KINEMATICHESKOM VOZBUZHDENII]**

I. N. GINZBURG (Khar'kovskii Institut Inzhenerov Kommunal'nogo Stroitel'stva, Kharkov, Ukrainian SSR) Problemy Mashinostroeniia (ISSN 0131-2928), no. 22, 1984, p. 28-34. In Russian. refs

Nonlinear differential equations are obtained which describe the relative motion of an elastic bar under arbitrary kinematic excitation of the supporting body. Linear equations of relative motion are integrated for the case of uniform rotation of the supporting body about the axis normal to the guiding plane and for the case of pulsed acceleration. The longitudinal and transverse displacements of the bar are calculated for various angular velocities, pulse lengths, and geometric parameters of the system, and the results are presented in graphic form. V.L.

**A86-16821**

### EXPERIMENTAL CHARACTERIZATION OF CRACKS AT STRAIGHT ATTACHMENT LUGS

G. NICOLETTO (Bologna, Universita, Italy) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 22, no. 5, 1985, p. 829-838. refs

Lugs are widely used to connect aircraft components. As damage tolerance requirements become increasingly important for design qualification, the cracked-hole problem has received sustained attention because it is the prevalent failure initiation mode of the aircraft industry and lacks an exact stress intensity factor solution. The present work deals with an experimental characterization of cracked lugs, using frozen-stress photoelasticity. Corner, transitioning and through-the-thickness cracks are considered. Experimental stress intensity distributions are presented and discussed in relation to previous studies. Various effects on SIF are assessed. Author

**A86-16833**

### EXPERIMENTS WITH SEVERAL ELEMENTS FOR VISCOUS INCOMPRESSIBLE FLOWS

M. FORTIN (Universite Laval, Quebec, Canada) and A. FORTIN (Montreal, Universite, Montreal, Canada) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 5, Oct. 1985, p. 911-928. Research supported by the Ministere de l'Education du Quebec and NSERC. refs

A numerical procedure to eliminate internal nodes from elements designed to approximate incompressible flow problems is presented. Six elements in academic and industrial flow problems are compared, and their relative qualities are discussed. A surprising conclusion is that richer elements may behave less well than simple ones if a good enforcement of incompressibility is not maintained. Author

**A86-17032**

### ATTACHED CAVITATION AND THE BOUNDARY LAYER - EXPERIMENTAL INVESTIGATION AND NUMERICAL TREATMENT

J. P. FRANC and J. M. MICHEL (Grenoble I, Universite, Saint-Martin-d'Heres, France) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 154, May 1985, p. 63-90. refs

(Contract DRET-80-414; DRET-81-513)

Attached cavitation on a wall with continuous curvature is investigated on the basis of experiments carried out on various bodies (circular and elliptic cylinders, NACA 16 012 foil). Visualization of the boundary layer by dye injection at the leading edge shows that a strong interaction exists between attached cavitation and the boundary layer. In particular, it is shown that the cavity does not detach from the body at the minimum pressure point, but behind a laminar separation, even in largely developed cavitating flow. A detachment criterion which takes into account this link between attached cavitation and boundary layer is proposed. It consists of connecting a cavitating potential-flow calculation and a boundary-layer calculation. Among all the theoretically possible detachment points, the actual detachment point is chosen to be the one for which the complete calculation predicts a laminar separation just upstream. This criterion, applied to the NACA foil, leads to a prediction which is in good agreement with experimental results. Author

**A86-17043**

### LONGITUDINAL VORTICES IMBEDDED IN TURBULENT BOUNDARY LAYERS. I - SINGLE VORTEX

I. M. M. A. SHABAKA, R. D. MEHTA, and P. BRADSHAW (Imperial College of Science and Technology, London, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 155, June 1985, p. 37-57. refs

(Contract N00014-78-G-0032; NR PROJECT 061-256)

Detailed mean-flow and turbulence measurements have been made in a low-speed turbulent boundary layer in zero pressure gradient with an isolated, artificially generated vortex imbedded in it. The vortex was generated by a half-delta wing on the floor of the wind-tunnel settling chamber, so that the vortex entering the working section had the circulation as that originally generated, while axial-component velocity variations were very much reduced, relative to the local mean velocity, from values just behind the generator. The measurements show that the circulation around the vortex imbedded in the boundary layer is almost conserved, being reduced only by the spanwise-component surface shear stress. Therefore the region of flow affected by the vortex continues to grow downstream, its cross-sectional dimensions being roughly proportional to the local boundary-layer thickness. The behavior of the various components of eddy viscosity, deduced from measured Reynolds stresses, and of the various triple products, suggests that the simple empirical correlations for these quantities used in present-day turbulence models are not likely to yield flow predictions which are accurate in detail. Author

**A86-17071**

### DRIVE TRAIN SIMULATION REQUIREMENTS FOR DEVELOPMENT OF HELICOPTER OVERRUNNING CLUTCHES

A. G. CHORY and J. J. CORSO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, Oct. 1985, p. 63-69. refs

Test methodology used to develop helicopter overrunning clutches is presented including static and fatigue test requirements, functional and environmental simulations and a description of the test facility required for representative aircraft drive system simulation. The facility includes a motor and hydroviscous drive clutch; a hydroviscous absorber brake; a motor to simulate overrunning; a self-contained hot/cold gearbox lubrication system; and a dedicated mini-computer for control of five feedback loops with built-in automatic shut down, alarm features, and on-line monitoring. This multipurpose facility was designed to permit development of all drive train components, with the clutch development requiring most of the available features. Author

**A86-17137#**

### A LINEARIZED THEORY FOR SWIRLING SUPERSONIC JETS AND ITS APPLICATION TO SHOCK-CELL NOISE

P. W. CARPENTER (Exeter, University, England) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1902-1909. Previously cited in issue 17, p. 3174, Accession no. A80-41628. refs

**A86-17791#**

### A METHODOLOGY FOR ANALYZING LASER-INDUCED STRUCTURAL DAMAGE

S. K. BRYAN (U.S. Air Force Academy, Colorado Springs, CO), P. J. TORVIK (USAF, Institute of Technology, Wright-Patterson AFB, OH), and V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1103-1105. Previously cited in issue 03, p. 326, Accession no. A85-13584. refs

**A86-18124**

### A GENERAL PURPOSE, MULTI-STAGE, COMPONENT MODAL SYNTHESIS METHOD

D. N. HERTING (Mac-Neal-Schwendler Corp., Los Angeles, CA) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 1, Aug. 1985, p. 153-164. refs

A general purpose algorithm for the dynamic analysis of large-order finite element structural models using real modal coordinates is presented. Each component substructure may be formulated to include free or fixed boundary modes, inertia relief displacement shapes, and physical displacements as generalized degrees of freedom. Capabilities are developed for transforming interior loads, such as aerodynamic effects, to the reduced set of coordinates. Theory and tests prove that the method duplicates results from most of the other popular methods by selecting various optional terms. The conclusion contains practical recommendations based upon several applications to structural analysis. Author

**A86-18409**

**GEAR TOOTH SURFACE FATIGUE TESTING WITH FULL SIZE TEST SPECIMENS**

R. J. DRAGO and H. J. NONEMAKER (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 18 p.

Attention is given to the test rig configurations and control and instrumentation systems of a major helicopter manufacturer's Gear Research Test Facility. The approach used at this facility for the surface durability testing of full size spur, helical and spiral bevel gears, in support of a helicopter transmission design effort, is demonstrated. Data analyses yield a mean S/N curve, unbiased standard deviation, and 99-percent confidence limits on the mean curve. O.C.

**A86-18410**

**HELICOPTER DRIVE SYSTEM BENCH TESTING**

D. L. JOHNSON (Bell Helicopter Textron, Inc., Transmission Bench Test Facility, Fort Worth, TX) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Such major helicopter rotor drive system components as gearboxes, driveshafts and masts must be subjected to laboratory development and qualification tests prior to entering service, in order to uncover and eliminate design deficiencies. Endurance and fatigue tests are then conducted to complete the qualification process. Testing takes place in isolated cells, and a computer-controlled data acquisition system monitors test specimen parameters. Power absorption and mechanical and electrical regenerative test stands are used in the cells. O.C.

**A86-18426**

**TESTING LARGE TRANSMISSIONS**

J. C. MACK and R. F. MCCANN (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Helicopter Testing Technology, Williamsburg, VA, October 29-November 1, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, 8 p.

Attention is given to the performance requirements and evaluation procedures that have been devised for large helicopter transmission tests, such as multiplex telemetry systems. Test requirements encompass the investigation of the relationship of tooth contact patterns to their stress fields, as well as the effects of vibratory excitations at operating speed, since undamped, high frequency vibratory forces can severely impact gear integrity. Computer-based data processing shortens the time required for data reduction and improves the accuracy of the results obtained. O.C.

**A86-18431**

**TORSIONAL LOW CYCLE FATIGUE OF SPLINE-ENDED DRIVE COMPONENTS**

C. P. HARDERSEN and T. VOTHANH (Kaman Aerospace Corp., Bloomfield, CT) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 1-1 to 1-16.

Spline-ended joints of three different kinds of steel materials (9315, 4340, 300 maraging) were tested for torsional low cycle fatigue. The experimental data, the S-N curve fitting and the construction method are presented. The noticeable discrepancies between the actual failure modes and the conventional design criteria for splines are observed. Discussions include allowance for scatter, explanation of a typical failure phenomenon, and an attempt at correlating experimental results with torsional fatigue theory, considering fatigue progression under combined bending and torsion. Some recommendations for an improvement of spline design techniques to predict low cycle torsional strength are proposed, mainly in the categories of spline geometry, material choices, and treatment of stress concentration. A design criteria approach is suggested to account for low cycle torsional fatigue in spline-ended joints. Author

**A86-18436**

**ANOTHER LOOK AT GENERALIZED S-N CURVE SHAPES**

C. ALBRECHT (Boeing Vertol Co., Philadelphia, PA) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 6-1 to 6-8. refs

With existing helicopter lifetimes being extended further and further by commercial use, service life extension programs (SLEP) and modernization programs, low-frequency, high-amplitude cyclic loads (GAG-trip cycle) are having an increasing impact on component lives. This is particularly true for drive system components. This paper presents an approach to establish S-N curve shapes, covering the full range of cyclic loading, including GAG-trip cycle loads to be used for the life calculations. Nondimensionalized S-N curves and constant life diagrams are presented for typical helicopter aluminum and steel alloys. The main focus of this paper is to identify a means to permit generation of families of full range S-N curves, using only a limited number of high-cycle fatigue tests. Author

**A86-18739**

**AN INTRODUCTION TO THE THEORY OF NONLINEAR VIBRATIONS OF AIRCRAFT STRUCTURES [VVEDENIE V TEORIIU NELINEINYKH KOLEBANII AVIAKONSTRUKTSII]**

R. E. LAMPER Moscow, Izdatel'stvo Mashinostroenie, 1985, 88 p. In Russian. refs

The book is concerned with some typical problems encountered in the study of nonlinear vibrations of aircraft structures, such as skin panels, adjustable stabilizer, landing gear struts, and bluff parts of the airframe. Both qualitative methods of analysis on a phase plane and analytical methods are examined. Particular attention is given to small-parameter methods, including the Krylov-Bogoliubskii-Mitropolskii asymptotic method and the Van der Pol method. Finally, the principal characteristics of parametric vibrations are discussed. V.L.

**A86-18907**

**HEAT TRANSFER AT THE LATERAL SURFACE OF A BLUNT CONE DURING THE ABSORPTION OF THE ENTROPY LAYER BY A LAMINAR OR A TURBULENT BOUNDARY LAYER [TEPLOOBMEN NA BOKOVOI POVERKHNOSTI ZATUPLENNOGO KONUSA PRI POGLOSHCHENII ENTROPIINOGO SLOIA LAMINARNYM I TURBULENTNYM POGRANICHNYM SLOEM]**

IU. N. ERMAK, N. P. KOLINA, and A. IA. IUSHIN PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1985, p. 65-69. In Russian. refs

The effect of entropy layer absorption on the aerodynamic heating of a blunt round cone with a half-angle of taper of 10 deg is investigated experimentally and analytically for Mach 6.1 and 8. Similarity parameters are obtained for heat transfer under conditions of entropy layer absorption by a turbulent boundary layer. The experimental and analytical results are processed in terms of similarity parameters for laminar and turbulent boundary layer flows. The results are then used to obtain interpolation formulas for the heat transfer parameter. V.L.

**N86-14244#** Gesellschaft fuer Mathematik und Datenverarbeitung, St. Augustin (West Germany).

**DEVELOPMENT OF MULTIGRID ALGORITHMS FOR PROBLEMS FROM FLUID DYNAMICS**

K. BECKER and U. TROTTENBERG *In* DGLR The State of Development Research in Numerical Aerodynamics in West Germany p 112-120 1984 refs In GERMAN

Avail: NTIS HC A08/MF A01

Multigrid algorithms are developed to demonstrate multigrid technique efficiency for complicated fluid dynamics problems regarding error reduction and discretization accuracy. Subsonic potential 2-D flow around a profile is studied as well as rotation-symmetric flow in a slot between two rotating spheres and the flow in the combustion chamber of Otto engines. The study of the 2-D subsonic potential flow around a profile with the multigrid algorithm is discussed. Author (ESA)

**N86-14514#** Army Test and Evaluation Command, Aberdeen Proving Ground, Md.

**COLD REGIONS LOGISTIC SUPPORTABILITY TESTING OF ELECTRONIC, AVIONIC AND COMMUNICATIONS EQUIPMENT Final Report, on Test Operations Procedure**

20 Jun. 1985 28 p

(AD-A158887; TOP-6-4-007) Avail: NTIS HC A03/MF A01 CSCL 15E

This document describes methods and techniques necessary to perform a logistic supportability test of electronic, avionic, and communications equipment in a cold regions environment. GRA

**N86-14532*#** Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.

**INVESTIGATION OF CHEMICALLY-REACTING SUPERSONIC INTERNAL FLOWS Progress Report**

T. CHITSOMBOON and S. N. TIWARI Sep. 1985 45 p refs

(Contract NAG1-423)

(NASA-CR-176363; NAS 1.26:176363) Avail: NTIS HC A03/MF A01 CSCL 20D

This report covers work done on the research project Analysis and Computation of Internal Flow Field in a Scramjet Engine. The work is supported by the NASA Langley Research Center (Computational Methods Branch of the High-Speed Aerodynamics Division) through research grant NAG1-423. The governing equations of two-dimensional chemically-reacting flows are presented together with the global two-step chemistry model. The finite-difference algorithm used is illustrated and the method of circumventing the stiffness is discussed. The computer program developed is used to solve two model problems of a premixed chemically-reacting flow. The results obtained are physically reasonable. Author

**N86-14538#** Pennsylvania State Univ., University Park. Applied Research Lab.

**NUMERICAL APPROXIMATION OF THE TOTAL DRAG OF A BODY IN A TUBE**

K. C. KAUFMAN 25 Jun. 1985 43 p

(Contract N00024-79-C-6043)

(AD-A159548; ARL/PSU/TM-85-106) Avail: NTIS HC A03/MF A01 CSCL 20D

A study is made of numerical methods to approximate the total drag coefficient of an axisymmetric body in a tube. An analytical relationship for the drag coefficient is obtained via a standard open system control volume analysis. This relationship is found to be difficult to apply numerically using available numerical tools, leading to an approximation of the drag coefficient by neglecting the tube wall skin friction and the pressure distribution across the tube radius near the body tail. The resulting drag coefficient approximation, which accounts for tunnel blockage and horizontal buoyancy effects, is found to provide a good estimate to available experimental data for an unheated body. The approximation makes use of currently available numerical codes for axisymmetric inviscid and boundary layer flow. Numerical obtained drag distributions over a range of Reynolds numbers are compared with experimental drag data for the unheated laminar flow body in the Garfield Thomas 48-inch diameter water tunnel. Author (GRA)

**N86-14554*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FORMATION AND CHARACTERIZATION OF SIMULATED SMALL DROPLET ICING CLOUDS**

R. D. INGEBO Jan. 1986 13 p refs Proposed for presentation at the 24th Aeospace Sciences Meeting, Reno, Nev., 6-8 Jan. 1986; sponsored by AIAA

(NASA-TM-87180; E-2828; NAS 1.15:87180) Avail: NTIS HC A02/MF A01 CSCL 14B

Two pneumatic two-fluid atomizers operating at high liquid and gas pressures produced water sprays that simulated small droplet clouds for use in studying icing effects on aircraft performance. To measure median volume diameter, MVD or D sub v.5, of small droplet water sprays, a scattered-light scanning instrument was developed. Drop size data agreed fairly well with calculated values at water and nitrogen pressures of 60 and 20 psig, respectively, and at water and nitrogen pressures of 250 and 100 psig, respectively, but not very well at intermediate values of water and nitrogen pressure. MVD data were correlated with D sub 0, W sub N, and W sub w, i.e., orifice diameter, nitrogen, and water flowrate, respectively, to give the expression for MVD in microns. Author

**N86-14555*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THREE-DIMENSIONAL, TRANSONIC ROTOR FLOW FIELD RECONSTRUCTED FROM HOLOGRAPHIC INTERFEROGRAM DATA**

J. K. KITTLESON, Y. H. YU, and F. BECKER (Max-Planck-Inst. fuer Stroemungsforschung, Goettingen, West Germany) Oct. 1985 21 p refs

(NASA-TM-86816; REPT-85347; NAS 1.15:86816; USAAVSCOM-TR-85-A-10) Avail: NTIS HC A02/MF A01 CSCL 14E

Holographic interferometry and computer-assisted tomography (CAT) are used to determine the transonic flow field of a model rotor blade in hover. A pulsed ruby laser records 40 interferograms with a 61 cm-diam view field near the model rotor-blade tip operating at a tip Mach number of 0.90. After digitizing the interferograms and extracting fringe-order functions, the data are transferred to a CAT code. The CAT code then calculates pressure coefficients in several planes above the blade surface. The values from the holography-CAT method compare favorably with previously obtained numerical computations and laser velocimeter measurements at most locations near the blade tip. The results demonstrate the technique's potential for three-dimensional transonic rotor flow studies. Author

**N86-14615#** Systems Technology, Inc., Hawthorne, Calif.

**METHODOLOGIES FOR THE DIRECT DIGITAL CONTROL OF HIGHLY FLEXIBLE VEHICLES Final Report, Jul. 1982 - Sep. 1984**

D. MCRUER, R. F. WHITBECK, and R. E. MAGDALENO Feb. 1985 146 p

(Contract F33615-82-C-3614)

(AD-A158448; STI-TR-1193-1; AFWAL-TR-84-3104) Avail: NTIS HC A07/MF A01 CSCL 01C

This report presents methodologies for the direct digital control of vehicles with flexible modes. The techniques yield robust control system designs with modest or minimal requirements on the number of sensors and control actuators. The digital system techniques used include primarily the w-transforms for direct design and stability assessment, and the hybrid frequency response, for assessment and understanding of digital system peculiarities. The sawtooth Bode is used as the basic control system design concept. These three elements are applied to several examples, including a comprehensive case study for a fighter aircraft flight and flexible mode control system. Both continuous and discrete system designs are considered and the continuous system characteristics are contrasted with an optimal control design. This comparison pinpoints some of the features needed to make optimal control procedures more practical and mature for flexible vehicle control applications. An important step is taken in this direction by determining the nature of performance criteria which yield, for an example case, a highly robust, extremely simple controller derived from an optimal control procedure. GRA

**N86-14667*#** Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
**THREE-DIMENSIONAL ELASTIC-PLASTIC FINITE-ELEMENT ANALYSIS OF FATIGUE CRACK PROPAGATION Final Report, 1 Jun. - 1 Nov. 1985**
G. L. GOGLIA and R. G. CHERMAHINI Nov. 1985 60 p refs
(Contract NAG1-529)
(NASA-CR-176415; NAS 1.26:176415) Avail: NTIS HC A04/MF A01 CSCL 20K

Fatigue cracks are a major problem in designing structures subjected to cyclic loading. Cracks frequently occur in structures such as aircraft and spacecraft. The inspection intervals of many aircraft structures are based on crack-propagation lives. Therefore, improved prediction of propagation lives under flight-load conditions (variable-amplitude loading) are needed to provide more realistic design criteria for these structures. The main thrust was to develop a three-dimensional, nonlinear, elastic-plastic, finite element program capable of extending a crack and changing boundary conditions for the model under consideration. The finite-element model is composed of 8-noded (linear-strain) isoparametric elements. In the analysis, the material is assumed to be elastic-perfectly plastic. The cycle stress-strain curve for the material is shown Zienkiewicz's initial-stress method, von Mises's yield criterion, and Drucker's normality condition under small-strain assumptions are used to account for plasticity. The three-dimensional analysis is capable of extending the crack and changing boundary conditions under cyclic loading. Author

**N86-15300*#** Boeing Vertol Co., Philadelphia, Pa.
**PLANNING, CREATING AND DOCUMENTING A NASTRAN FINITE ELEMENT MODEL OF A MODERN HELICOPTER**
R. GABAL, D. REED, R. RICKS, and W. KESACK *In* NASA. Ames Research Center Rotorcraft Dynamics 1984 p 307-324 Nov. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 20K

Mathematical models based on the finite element method of structural analysis as embodied in the NASTRAN computer code are widely used by the helicopter industry to calculate static internal loads and vibration of airframe structure. The internal loads are routinely used for sizing structural members. The vibration predictions are not yet relied on during design. NASA's Langley Research Center sponsored a program to conduct an application of the finite element method with emphasis on predicting structural vibration. The Army/Boeing CH-47D helicopter was used as the modeling subject. The objective was to engender the needed trust in vibration predictions using these models and establish a body of modeling guides which would enable confident future prediction of airframe vibration as part of the regular design process. Author

**N86-15447#** Joint Publications Research Service, Arlington, Va.
**WEST EUROPE REPORT: SCIENCE AND TECHNOLOGY**
13 Aug. 1985 68 p Transl. into ENGLISH from various West European articles
(JPRS-WST-85-024) Avail: NTIS HC A04/MF A01

Several topics related to Western Europe's technology and science efforts are discussed. The Airbus, the use of laser doppler velocimeters for wind tunnel measurements, prop-fan technology, biotechnology, and microelectronics are among the topics covered.

**N86-15518#** Systems Control, Inc., West Palm Beach, Fla.
**VHF-AM COMMUNICATIONS EQUIPMENT SELECTION AND INSTALLATION PRACTICES FOR HELICOPTERS Final Report, Sep. 1983 - Mar. 1984**
E. H. BOLZ and L. D. KING Sep. 1985 46 p refs
(Contract DTFA01-80-C-10080)
(DOT/FAA/PM-85/8) Avail: NTIS HC A03/MF A01

The problems helicopter operators face when using VHF communications within typical operating environments where coverage by the network of ground stations may be deficient are addressed. This is of particular interest to IFR helicopter operators. The specific reasons why communications effectiveness can be limited in mountainous or remote regions, considering typical low helicopter operating altitudes, are reviewed. Recommendations to operators for improving the airborne VHF installation, and therefore improving its coverage capabilities, are presented. Several installation-related factors are discussed. These include the characteristics of the hardware, i.e., the transceiver and the antenna, and the characteristics of the installation, including antenna installation and resulting coverage pattern, the cable run, the effects of signal availability and ways of maximizing the capture of the available signal. A set of procedures is presented which allows operators to evaluate numerically the benefit in terms of signal strength or sensitivity they may expect given that they make specific improvements to a given actual or planned installation. Author

**N86-15528#** Air Force Academy, Colo.
**NUMBER OF TARGETS THREATENED SIMULTANEOUSLY (NOTTS) IN CONJUNCTION WITH OVER THE HORIZON BACK-SCATTER (OTHB) RADAR COVERAGE Final Report, Jan. 1984 - Dec. 1985**
J. F. SHEEDY Aug. 1985 74 p
(AD-A159304; AD-F250300; USAFA-TR-85-9) Avail: NTIS HC A04/MF A01 CSCL 17I

Number of Targets Threatened Simultaneously (NOTTS) is a measure of the presence (in a background of unknowns) of a surprise attack on the U.S. retaliatory force. Four NOTTS indicators PEAK, KURTOSIS, RIDGE, and P1, P2, and P3 are defined and evaluated using the J5YA Raid Recognition Algorithm for a bomber or cruise missile raid against SAC and C3 target sets. Scatter charts showing background noise produced by commercial traffic, raid plus noise combined are presented and used to describe the setting of reaction thresholds. The effect of time of day, probability of radar detection, and the choice of target set and raid design on reaction threshold are discussed. Although ideal settings of indicators are practical in the cases discussed, attention is drawn to the limited data available for modeling of unknowns in OTHB coverage. GRA

**N86-15575#** Joint Publications Research Service, Arlington, Va.
**BASIC CHARACTERISTICS OF RADAR ANTENNA WITH SYNTHESIZED APERTURE TRACKING ARBITRARY MOTION OF AIRCRAFT Abstract Only**
Y. S. ITSKHOKI, N. A. SAZONOV, and Y. F. TOLSTOV *In its* USSR Report: Electronics and Electrical Engineering (JPRS-UEE-85-006) p 14 30 Apr. 1985 Transl. into ENGLISH from Radiotekhnika i Elektronika (Moscow, USSR), v. 29, no. 11, Nov. 1984 p 2164-2172
Avail: NTIS HC A05/MF A01

A problem in tracking the motion of an aircraft which carries a radar antenna with synthesized aperture are random phase fluctuations of the input signal. These fluctuations, caused by instability of the aircraft trajectory and elastic vibrations of the aircraft structure as well as by tropospheric effects and intentional interference, worsen the azimuth resolution and the accuracy of azimuth determination. This situation is analyzed here for the more general case of arbitrary motion of the aircraft and arbitrary *observation angle* rather than for rectilinear motion and lateral observation. The output signal serves as performance criterion, its waveform being determined principally by the radiation pattern of the real antenna and its modulus remaining approximately constant over the aperture synthesization time. On this basis, the trajectory of the phase center of the real antenna can be approximated with a quadratic parabola. For given wavelength and elevation angle, the best azimuth resolution attainable with signal processing by the straight convolution method (second target on observation line) is determined by the length of aperture synthesization time, the tangential component of aircraft velocity, and the form of the weight function. In the absence of phase fluctuations, the error of azimuth determination is in this case determined only by the resolving power of the radar with synthesized antenna aperture. Signal processing by the harmonic analysis method introduces some defocusing, which worsens the resolution, even in the absence of phase fluctuations. Author

**N86-15625*#** Arizona State Univ., Tempe.
**HEAT TRANSFER CHARACTERISTICS WITHIN AN ARRAY OF IMPINGING JETS. EFFECTS OF CROSSFLOW TEMPERATURE RELATIVE TO JET TEMPERATURE Final Report**
L. W. FLORSCHUETZ and C. C. SU Washington NASA Oct. 1985 175 p refs
(Contract NSG-3075)
(NASA-CR-3936; E-2696; NAS 1.26:3936; CR-R-R85020) Avail: NTIS HC A08/MF A01 CSCL 20D

Spanwise average heat fluxes, resolved in the streamwise direction to one stream-wise hole spacing were measured for two-dimensional arrays of circular air jets impinging on a heat transfer surface parallel to the jet orifice plate. The jet flow, after impingement, was constrained to exit in a single direction along the channel formed by the jet orifice plate and heat transfer surface. The crossflow originated from the jets following impingement and an initial crossflow was present that approached the array through an upstream extension of the channel. The regional average heat fluxes are considered as a function of parameters associated with corresponding individual spanwise rows within the array. A linear superposition model was employed to formulate appropriate governing parameters for the individual row domain. The effects of flow history upstream of an individual row domain are also considered. The results are formulated in terms of individual spanwise row parameters. A corresponding set of streamwise resolved heat transfer characteristics formulated in terms of flow and geometric parameters characterizing the overall arrays is described. E.A.K.

**N86-15626*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**COMPUTATIONAL FLUID DYNAMICS AT NASA AMES AND THE NUMERICAL AERODYNAMIC SIMULATION PROGRAM**
V. L. PETERSON Sep. 1985 23 p refs
(NASA-TM-86769; REPT-85321; NAS 1.15:86769) Avail: NTIS HC A02/MF A01 CSCL 20D

Computers are playing an increasingly important role in the field of aerodynamics such as that they now serve as a major complement to wind tunnels in aerospace research and development. Factors pacing advances in computational aerodynamics are identified, including the amount of computational power required to take the next major step in the discipline. The four main areas of computational aerodynamics research at NASA Ames Research Center which are directed toward extending the state of the art are identified and discussed. Example results obtained from approximate forms of the governing equations are presented and discussed, both in the context of levels of computer power required and the degree to which they either further the frontiers of research or apply to programs of practical importance. Finally, the Numerical Aerodynamic Simulation Program--with its 1988 target of achieving a sustained computational rate of 1 billion floating-point operations per second--is discussed in terms of its goals, status, and its projected effect on the future of computational aerodynamics. Author

**N86-15627*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**NUMERICAL SIMULATION OF VISCOUS SUPERSONIC FLOW OVER A GENERIC FIGHTER CONFIGURATION**
D. S. CHAUSSEE, G. BLUM (Boeing Co., Seattle, Wash.), and J. WAI (Boeing Co., Seattle, Wash.) Dec. 1985 10 p refs
(NASA-TM-86823; A-85436; NAS 1.15:86823) Avail: NTIS HC A02/MF A01 CSCL 20D

A procedure is presented, as well as some results, to calculate the flow over a generic fighter configuration. A parabolized marching Navier-Stokes code is used to obtain the solution over a wing-canopy body. The flow conditions simulate supersonic cruise with a freestream Mach number of 2.169 and angles of attack of 4 and 10 deg. The body surface is considered to be an adiabatic wall and the flow is assumed to be turbulent for the given Reynolds number. Author

**N86-15647** Department of the Air Force, Washington, D.C.
**FERROMAGNETIC RESONANCE PROBE LIFTOFF SUPPRESSION APPARATUS Patent**
T. J. DAVIS and P. L. TOMERAASEN, inventors (to Air Force) 9 Jul. 1985 5 p Supersedes AD-D010243
(AD-D011913; US-PATENT-4,528,506; US-PATENT-APPL-SN-444004; US-PATENT-CLASS-324-225)
Avail: US Patent and Trademark Office CSCL 14B

A liftoff suppression apparatus is described which utilizes a liftoff sensing coil to sense the amount a ferromagnetic resonance probe lifts off the test surface during flaw detection. The liftoff signal is used to modulate the probe's field modulating coil to suppress the liftoff effects. Author (GRA)

**N86-15651*#** Pratt and Whitney Aircraft, East Hartford, Conn.
**DYNAMIC GAS TEMPERATURE MEASUREMENT SYSTEM. VOLUME 2: OPERATION AND PROGRAM MANUAL**
P. T. PURPURA 1983 151 p Sponsored by NASA
(NASA-CR-168267; NAS 1.26:168267) Avail: NTIS HC A08/MF A01 CSCL 14B

The hot section technology (HOST) dynamic gas temperature measurement system computer program acquires data from two type B thermocouples of different diameters. The analysis method determines the in situ value of an aerodynamic parameter T, containing the heat transfer coefficient from the transfer function of the two thermocouples. This aerodynamic parameter is used to compute a fequency response spectrum and compensate the dynamic portion of the signal of the smaller thermocouple. The calculations for the aerodynamic parameter and the data compensation technique are discussed. Compensated data are presented in either the time or frequency domain, time domain data as dynamic temperature vs time, or frequency domain data. E.A.K.

**N86-15668*#** Institut Franco-Allemand de Recherches, St. Louis (France).
**STUDY OF HIGH SPEED COMBUSTION FLOWS BY LASER VELOCIMETRY**
H. J. SCHAEFER 26 Oct. 1984 29 p Presented at NASA Langley Research Center Visit, Hampton, VA., 5 Oct. 1984 Sponsored in part by NASA
(NASA-CR-176439; NAS 1.26:176439; ISL-CO-232/84) Avail: NTIS HC A03/MF A01

The feasibility of laser velocimetry in a high temperature jet was assessed in a model of an aircraft engine combustor. Experiments show that the problems encountered in measuring combustion flow can flow can be overcome by a carefully designed optical set-up and an appropriate signal processing and data acquisition system. Laser Doppler velocimetry provides useful information about coherent structures in hot free jets. The measurements agree with measurements in an isothermal jet. Author (ESA)

**N86-15671#** Department of the Air Force, Washington, D.C.
**ADAPTER PALLET SYSTEM Patent Application**
F. R. HARRIS, inventor (to Air Force) 11 Dec. 1984 17 p
(AD-D011858; US-PATENT-APPL-SN-680611) Avail: NTIS HC A02/MF A01 CSCL 15E

A bifurcated adapter pallet system for providing an interface between the 463L and ISO systems is presented. Each adapter has mounting faces to attach to an ISO container at the container corner fittings and 463L tongues for restraint by 463L equipment. The ISO/463L adapter pallet facilitates efficient and appropriate tiedown and transportation of ISO cargo by means of vehicles equipped with the 463L handling system. GRA

## 13

## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**N86-14826#** Chicago Univ., Ill. Dept. of Geophysical Sciences.
**DOWNBURST: MICROBURST AND MACROBURST**
T. T. FUJITA 1985 131 p refs
(PB85-148880; SMRP-RP-210; LC-85-50115) Avail: NTIS HC A07/MF A01 CSCL 04B

Until several years ago, microbursts and tornadoes were regarded as being unrelated. An amazing similarity between these severe storms is presented. A tornado is an intense misocyclone in which the swirling air rushes upward, while a microburst, at inflow and downflow levels, is surrounded by a misocyclone in which the swirling air rushes downward. The history of downburst identification is presented, as is some observations of macrobursts and microbursts. How microburst is related to some aircraft accidents is also studied. Author

**N86-15771*#** Mississippi Univ., University.
**MOBILE INTERCEPT OF STORMS**
R. T. ARNOLD *In* NASA. Marshall Space Flight Center NASA/MSFC FY-85 Atmospheric Processes Research Review p 7-8 Oct. 1985 refs
Avail: NTIS HC A07/MF A01 CSCL 04B

A NASA U2 research aircraft was used to fly over storms in the area of Oklahoma, southern Kansas, and north Texas. The primary goal was to acquire lightning data to serve as ground truth for U2 overflights. A mobile laboratory was instrumented and the storm intercept was coordinated through communication to the U2 provided by airplane guidance at NSSL and through direct communication with the U2 pilot from a portable transceiver in the mobile lab. The flights were successful in spite of an unusual sparsity of storm activity during the operational period and an early termination of the scheduled flight program. Severe storms data was gathered within the area of Oklahoma with good Doppler radar coverage. A vehicle followed a mobile lab and released instrumented balloons. A standard meteorological rawinsonde was used as was a balloon-borne electric field meter. There was success in flying, tracking, and receiving data from mobily launched balloons on several days. Author

**N86-15838#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abteilung Wolkenphysik.
**RESULTS OF ICING FLIGHTS IN WINTER 1983/84: ICE ACCRETION THICKNESS IN CORRELATION WITH CLOUD PHYSICAL PARAMETERS, OBJECT AND CLOUD PARAMETERS**
H. E. HOFFMANN, R. ROTH, and J. DEMMEL May 1985 46 p refs In GERMAN; ENGLISH summary
(DFVLR-FB-85-39; ISSN-0171-1342) Avail: NTIS HC A03/MF A01; DFVLR, Cologne DM 16

Twenty-five icing flights on a DO 28 research aircraft were carried out to determine the correlation between ice accretion thickness on standard cylinders and cloud physical parameters (liquid water content, temperature, particle phase and size), object parameters (cylinder diameter) and cloud parameters (cloud altitude, location coordinates, time, stratus or cumulus). The relationship between ice accretion thickness and water content is demonstrated with the ice accretion model of the Canadian National Research Council. Effects of the cloud particle size on ice accretion thickness could not be shown. The ice accretion thickness change due to liquid water content depends on cylinder diameter. Liquid water content, ice accretion thickness, and icing degree increase with altitude. Stratus or cumulus has no effect on the ice accretion thickness. Author (ESA)

## 14

## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**N86-15886#** Joint Publications Research Service, Arlington, Va.
**METHOD OF CALCULATING ANGULAR DIMENSIONS OF FLIGHT VEHICLE COCKPIT CANOPY CASINGS**
A. V. LEKAREV *In its* USSR Report: Space Biology and Aerospace Medicine, Vol. 19, No. 4, Jul. - Aug. 1985 (JPRS-USB-85-006) p 120-124 4 Nov. 1985 refs Transl. into ENGLISH from Kosmich. Biol. i Aviakosmich. Med. (Moscow), v. 19, no. 4, Jul. - Aug. 1985 p 81-83
Avail: NTIS HC A08

The view from flight vehicle (FV) cockpits is an important factor in assuring flying safety and providing comfortable conditions for the pilot's visual observation of space outside the cockpit. At the present time, transparent parts of most cockpits in different types of FV are executed in the form of flat panels installed into the metal frame of the cockpit canopy. Presence of opaque components (casings) in the cockpit canopy results in obscuring part of the outside area, which worsens viewing conditions from the pilot's work place. In order to improve the view from FV cockpits with flat transparent parts, a method was developed for calculating the angular dimensions of casings (seams) on the basis of distinctions of human binocular vision. The proposed method makes it possible to meet the requirements as to strength features of the canopy frame and provide for comfortable viewing conditions outside the cockpit. The method is based on crossed diplopia in an empirical horopter from a point of the cyclopic eye of the observer. B.W.

# 15

# MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-17781#**
**INTERACTIVE GRAPHICS FOR GEOMETRY GENERATION - A PROGRAM WITH A CONTEMPORARY DESIGN**
W. F. LABOZZETTA and P. E. COLE (Lockheed-Georgia Co., Marietta, GA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1054-1058. Research supported by the Lockheed-Georgia Independent Research and Development Program. Previously cited in issue 03, p. 349, Accession no. A85-13502.

**A86-17830#**
**GENERAL DYNAMICS SIMULATION AND ARTIFICIAL INTELLIGENCE INTEGRATION**
R. D. TEICHGRAEBER (General Dynamics Flight Simulation Laboratory, Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 4 p.
(AIAA PAPER 85-4048)

An initial integration of artificial intelligence (AI) in the aircraft cockpit is described. A prototype expert system is to be implemented as a pilot's assistant in a simulation environment. The flight simulation environment provides a realistic vehicle for the critical evaluation of the expert system. Plans and objectives for General Dynamics' AI simulation efforts are presented. D.H.

**A86-18438**
**A COMPUTERIZED AUTOMATIC CONTROL SYSTEM FOR STRUCTURAL TESTING**
H. M. LAWTON (Bell Helicopter Textron, Fort Worth, TX) IN: Helicopter Fatigue Specialists' Meeting, St. Louis, MO, October 16-18, 1984, Proceedings . Alexandria, VA, American Helicopter Society, 1984, p. 8-1 to 8-14.

This paper describes an advanced computerized system which was custom designed and developed for automatically controlling complex structural fatigue tests. The background and the system hardware, operating procedures, and capabilities are described. Examples of actual test operations are given, and the advantages of the systems are discussed. Author

**A86-18918**
**SIMPLE APPROXIMATIONS OF FUNCTIONS WITH ADDITIONAL CONSTRAINTS [PROSTYE PRIBLIZHENIIA FUNKTSII S DOPOLNITEL'NYMI USLOVIIAMI]**
A. V. ANTONETS Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 25, Nov. 1985, p. 1589-1598. In Russian. refs

Simple formulas and algorithms for the criterial approximation of functions are proposed which are relevant to problems in practical aerodynamics. For the unified numerical solution of higher-order systems of linear equations with a rectangular matrix, a method of consecutive 'minimal' refinements is developed whereby computational process with automatic control of rounding-off error accumulation invariably yields an accurate or an approximate 'compromise' solution. Examples of correlations of the aerodynamic coefficients of bodies are presented which can lead to the development of an efficient method for calculating aerodynamic characteristics using reference bodies. V.L.

**N86-14960#** Southwest Research Inst., San Antonio, Tex.
**DIGITAL SERVOCONTROLLER SYSTEM. VOLUME 1: OPERATIONS MANUAL Final Report, 6 Jul. 1983 - 6 Nov. 1984**
J. LOPEZ and K. MILLER Feb. 1985 48 p
(Contract F33615-83-C-3201)
(AD-A158392; SWRI-14-7676-060-VOL-1;
AFWAL-TR-84-3117-VOL-1) Avail: NTIS HC A03/MF A01
CSCL 09B

This final report describes an exploratory development effort for the design and fabrication of a digital servocontroller system for load control in full-scale air-frame fatigue tests. Each digital controller replaces four analog controllers. The LSI-11/23 microcomputer in the digital controller executes a PI algorithm to implement direct digital control. It may operate in a stand-alone mode or as a slave processor to a master computer via fiber optic link. Other programmable features specifying loop parameters, building load profiles, adjusting control system gains and monitoring alarm and abort conditions. GRA

**N86-14982#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**THE INTERACTIVE GENERATION OF ALPHANUMERICS AND SYMBOLOGY WITH DESIGNS ON THE FUTURE M.S. Thesis**
K. A. ADAMS Jun. 1985 237 p Original contains color illustrations
(AD-A159218; AFIT/GCS/MA/85J-2) Avail: NTIS HC A11/MF A01 CSCL 09B

This thesis investigated the available methods for implementing human-computer interfaces using sophisticated graphics systems, with the goal of designing and implementing an advanced graphics development environment. Such a developmental laboratory is necessary to support current and futuristic crew station design for display-oriented cockpits. The result of this effort was the development system DESIGNS. The DESIGNS software system was tailored specifically for real-time, pilot-in-the-loop, research and development simulation. Critical features of such a system include fast turn-around time, and the capability to expand as enhanced tools are developed. The resulting system supports interactive development of heads-up and heads-down display symbology. It generates correct display formatting information for multiple target graphics devices. Future enhancements include rehosting to a more powerful workstation, preferably in Ada, and continued addition of graphics development tools supporting simulation needs. GRA

**N86-15003#** Oak Ridge National Lab., Tenn.
**NAVY AIRCRAFT SUPPORT DATA SYSTEMS STUDY: ECAMS/NALCOMIS INTEGRATION FEASIBILITY AND PROCEDURE**
K. R. CARR Aug. 1985 78 p
(Contract DE-AC05-84OR-21400)
(DE85-016977; ORNL/TM-9656) Avail: NTIS HC A05/MF A01

A study was done to identify and evaluate options for providing major improvements, extensions, and integration of essential automatic data processing equipment. This work is part of a long-term (several years duration) project in which Oak Ridge National Laboratory (ORNL) is establishing a center of excellence in support of the Department of the Navy in the Shipboard Nontactical Automated Data Processing Program. The program involves Honewell DPS-6 minicomputers, Digital Equipment Corporation PDP-11 minicomputers, Zenith personal computers, and magnetic tape recorders for surface processing of in-flight recorded data. The central issue addressed in this report is hardware and software options for interfacing the tape readers to the Honeywell equipment. Three leading candidate methods for providing the required interface were identified and analyzed. Variations of one method were also analyzed. A system-by-system comparison of the options is given in seven key areas: data transfer speed, data transmission distance capabilities, adaptability for processing classified data, flexibility and/or expandability, space required, logistics, and cost. DOE

**N86-15200*#** Lockheed Engineering and Management Services Co., Inc., Houston, Tex.
**INCREASING PRODUCTIVITY OF THE MCAUTO CAD/CAE SYSTEM BY USER-SPECIFIC APPLICATIONS PROGRAMMING**
S. M. PLOTROWSKI and T. H. VU *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 481-488 1985 refs
Avail: NTIS HC A25/MF A01 CSCL 09B

Significant improvements in the productivity of the McAuto Computer-Aided Design/Computer-Aided Engineering (CAD/CAE) system were achieved by applications programming using the system's own Graphics Interactive Programming language (GRIP) and the interface capabilities with the main computer on which the system resides. The GRIP programs for creating springs, bar charts, finite element model representations and aiding management planning are presented as examples. E.A.K.

# 16

# PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-16466*** Lockheed-Georgia Co., Marietta.
**TONE EXCITED JETS. I - INTRODUCTION**
H. K. TANNA and K. K. AHUJA (Lockheed-Georgia Co., Marietta, GA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 102, Sept. 8, 1985, p. 57-61. Research supported by Lockheed Internal Research and Development Program. refs
(Contract NAS3-21987)

The major objective of the present study is an understanding of the mechanism of broadband jet noise augmentation due to upstream excitation, in terms of the relationship between excitation characteristics, changes in large scale and/or small scale turbulence structure of the jet, and sound radiated to the far field under both static and simulated forward velocity conditions. A systematic set of acoustic measurements was accordingly made for a range of flow conditions in the acoustic research facilities of a large transport aircraft manufacturer. After analyzing acoustic results, turbulence measurements were made with a laser velocimeter for those jet conditions at which jet noise amplification was important. A theory was developed to account for static and in-flight simulation results. O.C.

**A86-16469*** Lockheed-Georgia Co., Marietta.
**TONE EXCITED JETS. IV - ACOUSTIC MEASUREMENTS**
K. K. AHUJA and D. F. BLAKNEY (Lockheed-Georgia Co., Marietta, GA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 102, Sept. 8, 1985, p. 93-117. Research supported by Lockheed Internal Research and Development Program. refs
(Contract NAS3-21987)

Attention is given to acoustic results from an experiment designed to deepen insight into the noise generated by a tone-excited jet, with emphasis on the mechanism of broadband jet noise amplification. Results are presented for both heated and unheated jets, with and without the effect of forward flight simulation over a range of excitation frequencies and levels, and for zero-order and first-order spinning modes. Broadband jet noise amplifications of up to 5 dB have been observed in this study. Relative velocity effects are the same for both excited and unexcited jets. It is concluded that small scale turbulence generates the additional broadband noise upon excitation of the jet by an upstream-injected discrete tone acoustic wave. O.C.

**A86-17138#**
**DISCRETE TONES GENERATED BY AN IMPINGING UNDEREXPANDED RECTANGULAR JET**
A. KROTHAPALLI (Florida State University, Tallahassee) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1910-1915. Previously cited in issue 10, p. 1478, Accession no. A83-26919. refs

**A86-17776*#**
**HELICOPTER LINEAR NOISE**
H. R. AGGARWAL (Helicopter Aerodynamics and Noise, Mountain View, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1025, 1026. Abridged. Previously cited in issue 01, p. 71, Accession no. A85-10832.
(Contract NCC2-191)

**A86-17783#**
**EVALUATION OF A CORRECTION FOR SOUND PROPAGATION THROUGH FREE-JET SHEAR LAYERS**
W. H. HERKES, F. G. STROUT (Boeing Commercial Airplane Co., Seattle, WA), and R. ROSS (Nationaal Lucht- en Ruimtevaart Laboratorium, Northeast Polder, Netherlands) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1065-1071. Previously cited in issue 10, p. 1476, Accession no. A83-25954. refs

**A86-17788#**
**NOISE OF COUNTER-ROTATION PROPELLERS WITH NONSYNCHRONOUS ROTORS**
D. B. HANSON and C. J. MCCOLGAN (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) Journal of Aircraft (ISSN 0021-8669), vol. 22, Dec. 1985, p. 1097-1099.

Counter-rotating propeller rotors, when run at different speeds, give rise to a noise spectrum-splitting phenomenon whose rotor-alone and interaction tones can be discriminated. Tabular data are presently given for such a rotor system, indicating mode behavior with frequency near the blade passing frequency and at twice that frequency. The mode-splitting behavior is found to constitute a powerful technique for noise source diagnoses in counter-rotating propellers. O.C.

**A86-18121**
**ACOUSTIC RECOGNITION OF AIRCRAFT TYPES IN FLIGHT**
I. YAMADA, A. YOKOTA, K. YAMAMOTO, and S. SHIMIZU (Kobayasi Institute of Physical Research, Kokubunji, Japan) Acoustical Society of Japan, Journal (ISSN 0388-2861), vol. 6, July 1985, p. 203-213. refs

A method for the acoustic recognition of aircraft types and flight patterns is presented, in which a discriminatory analysis slightly different from the ordinary one is used and peak-hold spectra (one-third octave band) relative to the peak value of A weighted sound pressure levels are selected for characteristic parameters of reference patterns. The newly developed procedure proved to be able to recognize aircraft types and flight patterns accurately irrespective of the mission of an airfield. Only a small number of parameters are required in the procedure. Author

**A86-18689#**
**NOISE GENERATED BY A STRETCHING VORTEX**
R. LEGENDRE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1985, p. 73-78.

A model of turbulence which consists of concentrated eddies has been used to illustrate a substantial source of aerodynamic noise. It is noted that the small vortex tubes between the large eddies, which have nonnegligible rotationals, probably have little effect on noise generation in virtue of their random signs and small peripheral velocities. Attention is given to the 'vortex stretching' phenomenon in three-dimensional flow, which is due to interactions with other vortices or with obstacles; calculations are presented which demonstrate this to be a powerful source of aerodynamic noise. O.C.

**N86-15053** Kansas Univ., Lawrence.

**01GENERAL AVIATION INTERIOR NOISE PROBLEM: SOME SUGGESTED SOLUTIONS Ph.D. Thesis**

R. NAVANEETHAN 1984 465 p

Avail: Univ. Microfilms Order No. DA8513813

The airborne noise transmission through aircraft sidewall is one of the important source, path combinations of the sound transmission into an aircraft cabin. A broad-based approach, i.e., laboratory investigation of sound transmission through panels, use of modern data analysis techniques and application to actual aircraft was used to determine methods to reduce general aviation interior noise. The experimental noise reduction characteristics of stiffened flat and curved panels with damping treatment are discussed. The experimental results of double-wall panels used in the general aviation industry are given. The effects of skin panel material, fiberglass insulation and trim panel material on the noise reduction characteristics of double-wall panels are investigated. These results are compared with the theoretical predictions from classical sound transmission theory for multilayered panels. The changes needed in the classical sound transmission theory for a better agreement are discussed. It is also shown that the same theory can successfully be used to design the interior noise control treatment of a new aircraft. Author

**N86-15113*#** Babcock and Wilcox Co., Alliance, Ohio. Research and Development Div.

**DEVELOPMENT OF OPTICAL DIAPHRAGM DEFLECTION SENSORS Final Report**

W. L. GHERING, D. VARSHNEYA, L. A. JEFFERS, R. T. BAILEY, and J. W. BERTHOLD Jun. 1985 49 p

(Contract NAS3-23712)

(NASA-CR-175008; NAS 1.26:175008; RDD:85:4101-12-01:01)

Avail: NTIS HC A03/MF A01 CSCL 20F

The objective of this project was to develop high-temperature pressure sensors using non-metallic components and optical sensing methods. The sensors are to operate over a temperature range from room temperature approx. 20C to 540C, to respond to internal pressure up to 690 kPa, to respond to external pressure up to 690 kPa, and to withstand external overpressure of 2070 kPa. Project tasks include evaluating sensing techniques and sensor systems. These efforts include materials and sensing method selection, sensor design, sensor fabrication, and sensor testing. Sensors are tested as a function of temperature, pressure, overpressure, and vibration. The project results show that high-temperature pressure sensors based on glass components and optical sensing methods are feasible. The microbend optical diaphragm deflection sensor exhibits the required sensitivity and stability for use as a pressure sensor with temperature compensation. for the microbend sensor, the 95% confidence level deviation of input pressure from the pressure calculated from the overall temperature-compensated calibration equation is 3.7% of full scale. The limitations of the sensors evaluated are primarily due to the restricted temperature range of suitable commercially available optical fibers and the problems associated with glass-to-metal pressure sealing over the entire testing temperature range. Author

**N86-16053#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abt. Turbulenzforschung.

**ON SECOND PROPAGATION IN RADIAL FAN CASINGS**

M. BARTENWERFER and T. GIKADI (Technical Univ., Berlin) Feb. 1985 34 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-957)

(DFVLR-FB-85-32; ISSN-0171-1342) Avail: NTIS HC A03/MF A01; DFVLR, Cologne DM 11

Sound propagation in radial fan hollow casings was studied for cylindrical and spiral-shaped casings of the same volume and width. After measurement of the sound reflection through the different casings a monopole or dipole sound source of reduced expansion at the casing cut-off was introduced and the frequency responses in the intake and outflow canals determined. The influence of casing geometry and the flow in the casing on the rejection level and on the system frequency responses was determined. The applicability of the one-mode approximation for description of the frequency responses was verified. Torsional sound in the outflow canal can be reduced with a phase-variable sound source synchronous with the rotation frequency at the cut-off. Author (ESA)

# 17

# SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-18537**

**HOW IS AIRLINE DEREGULATION WORKING?**

M. E. LEVINE Northrop University Law Journal of Aerospace, Energy, and the Environment (ISSN 0196-1489), vol. 5, Winter 1984, p. 11-16.

An assessment is made of the economic, operational and political consequences of U.S. airline industry deregulation since 1978, which have in many cases proved very different from what the authors of the Deregulation Act anticipated. Fuel prices tripled between 1978 and 1980; this very severe strain was compounded by the air traffic controller's strike of 1981. A world-wide recession prevented the profitable sale or lease abroad of excess aircraft. Nevertheless, the greater flexibility that the deregulated environment has made for is judged to have permitted airlines to meet these problems through otherwise inconceivable route system restructurings. O.C.

**A86-18538**

**AIRLINE DEREGULATION - WHAT WILL WE KNOW AND WHEN WILL WE KNOW IT?**

B. REIN (Wiley, Johnson and Rein, Washington, DC) Northrop University Law Journal of Aerospace, Energy, and the Environment (ISSN 0196-1489), vol. 5, Winter 1984, p. 17-23.

The present evaluation of the emerging consequences of U.S. Airlines' deregulation since 1978 notes that the greater freedom now found in route system choice appears to have led to higher levels of aircraft utilization. Attention is given to the questions of company failures and mergers, and the entry of new companies into the deregulated market. The extent to which travel agencies' control by existing airlines may impede the entrance of new airlines into the market is considered. O.C.

**A86-18848**

**RECENT DEVELOPMENTS IN AVIATION CASE LAW**

W. D. CARTER, JR. (Fulbright and Jaworski, Houston, TX) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 51, no. 1, 1985, p. 51-118. refs

A review of cases pertaining to recent aviation decisions is presented. Cases regarding federal subject matter, jurisdiction, personal jurisdiction, death in aircraft crashes in water, and federal removal are analyzed. Governmental liability and exception are studied. Cases concerning air carrier liability, including products damage and negligence, are examined. The applicability of the Warsaw Convention to notice of claims, limitation on liability, and damage recovery is investigated. General, and pilot qualification and airworthiness certificate insurance exclusions are discussed. Cases involving damage and the calculation of damage incurred in an aircraft accident are described. I.F.

**A86-18649**
**PILOT MEDICAL CERTIFICATION - PROCEDURES AND RECENT DEVELOPMENTS**
M. T. MCDERMOTT and R. J. SHERBACK (Joseph, Powell, McDermott, and Reiner, Washington, DC) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 51, no. 1, 1985, p. 119-154. refs

The role of the FAA in issuing the three classes of pilot medical certification is described. The FAA can deny, revoke, or require reexamination of medical certification; the pilot can counter a revocation by requesting reconsideration, special insurance or exemption, or review by the NTSB. The NTSB's review procedure is examined. Examples of court case requesting recertification are presented. FAA changes in the regulations governing coronary artery disease, alcoholism, and request for exemption procedures are discussed; these FAA changes limit the review power of the NTSB. NTSB changes in discovery, now allowing depositions and interrogations, are examined. The effect of a new FAA Administrator and Federal Air Surgeon on FAA policy is considered. I.F.

**N86-15205#** Air War Coll., Maxwell AFB, Ala.
**THE F/A-18 FIGHTER/ATTACK AIRCRAFT PROGRAM**
P. G. NICHOLSON May 1985 72 p
(AD-A159292; AD-F250300; AU-AWC-85-157) Avail: NTIS HC A04/MF A01 CSCL 05A

The history of the F/A-18 Fighter/Attack aircraft program is traced from its beginning as a result of the Naval Air Combat Fighter competition to 1984 when its future seems assured. Factors which affected the acquisition process are examined with a view to identifying those which might have significant influence on future tactical aircraft programs. Not surprisingly, the dominant factor is shown to be program cost and a number of strategies to minimize the effects of budgetary constraints are identified. The need for long-term planning and a rational comprehensive approach to controllable, programmatic factors is seen as essential in order to maintain adequate production levels in the face of less controllable economic factors. A coordinated approach to the operational requirements of the four United States tactical air forces is considered mandatory in order to promote commonality and develop multiple solutions. If this is not achieved, the F/A-18 program indicates that Congress is likely to intervene and play a more active role in areas where professional military expertise has traditionally held sway. GRA

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## GENERAL

**A86-18325**
**CLAUDE DORNIER - PIONEER OF AVIATION; ACADEMIC SEMINAR, TECHNISCHE UNIVERSITAET MUENCHEN, MUNICH, WEST GERMANY, OCTOBER 24, 1984, PAPERS [CLAUDE DORNIER - PIONIER DER LUFTFAHRT; AKADEMISCHE VORTRAGSVERANSTALTUNG, TECHNISCHE UNIVERSITAET MUENCHEN, MUNICH, WEST GERMANY, OCTOBER 24, 1984, VORTRAEGE]**
R. J. MEYER-JENS, ED. (Muenchen, Technische Universitaet, Munich, West Germany) Munich, West Germany, Technische Universitaet Muenchen, 1984, 200 p. In German. No individual items are abstracted in this volume.

A collection of papers on the development of modern flight technology is presented. The role of the engineer and the entrepreneur in that evolution is considered, and the history of aerodynamics is recapitulated. The growing use of simulation in the study of air traffic is discussed. C.D.

**A86-18481**
**LIZZY - THE FIRST BRITISH LIQUID PROPELLANT ROCKET MOTOR**
J. GRIFFITHS (Science Museum, London, England) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 38, Dec. 1985, p. 531-536. refs

Low-budget efforts by government-funded British researchers experimenting with liquid-fueled rocket concepts from 1941-43 are chronicled. The program was initiated to find a replacement for cordite as a rocket fuel. It was decided to follow the few published notes of Goddard and use LOX and gasoline. The immediate design problems were handling the LOX, building a combustion chamber, initiating the firing and delivering fuel to the combustion chamber. The goal was an engine that would produce 2000 lb thrust for 30 sec. Tests covered post-nozzle mixing of fuels and various nozzle geometries, chamber materials, flow rates and nozzle cooling techniques. A detailed pictorial summary of the first successful test, producing 1000 lb thrust, 7 mos after the program was initiated is provided. M.S.K.

**A86-19052#**
**AEROSPACE HIGHLIGHTS 1985**
Aerospace America (ISSN 0740-722X), vol. 23, Dec. 1985, p. 26-31, 34-37, 40-45 (43 ff.).

Brief technology development status assessments are presented for major fields in the aerospace industries and sciences, encompassing aspects of aircraft and missile propulsion, aircraft and spacecraft design, avionics and computer sciences, and advanced sensors. Attention is given to aeroacoustics, power supplies, air-breathing propulsion systems, aircraft design, C3I systems, liquid rocket and electric spacecraft propulsion, fluid dynamics, ground testing techniques, and lighter-than-air craft. Also discussed are advanced materials, lasers, software design, space processing of advanced materials, structural dynamics, V/STOL aircraft, interactive computer graphics, and life science and life-support systems. O.C.

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# SUBJECT INDEX

**AERONAUTICAL ENGINEERING** / *A Continuing Bibliography (Supplement 199)* APRIL 1986

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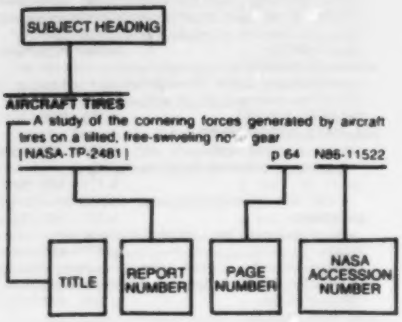
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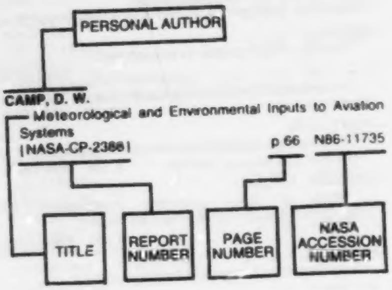

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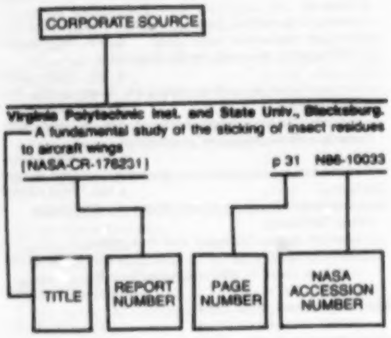
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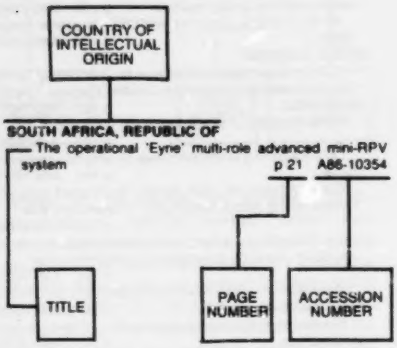
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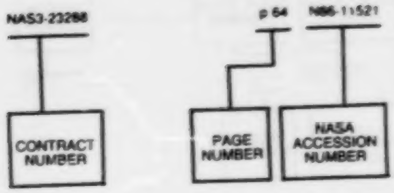

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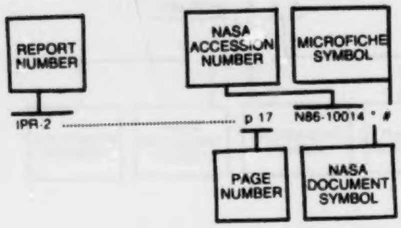

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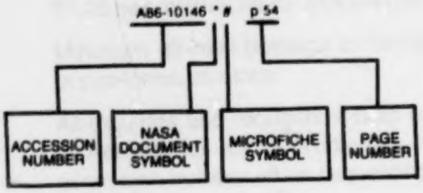

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**N86-10033*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.
**A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs
(Contract NAG1-300)
(NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.
Author

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**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS**
D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.
Author

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Aeronautical Engineering Pages 107-268 May 1986

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NASA SP-7037(200)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

## (Supplement 200)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in April 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Branch 1986
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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 484 reports, journal articles, and other documents originally announced in April 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

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# AERONAUTICAL ENGINEERING

## *A Continuing Bibliography (Suppl. 200)*

MAY 1986

## 01

## AERONAUTICS (GENERAL)

**A86-21055**
**AVIATION MAINTENANCE MANAGEMENT**
E. H. KING (Southern Illinois University, Carbondale, IL) Carbondale, IL, Southern Illinois University Press, 1986. 221 p. refs

The maintenance management concerns that confront the various levels of aviation supervision are discussed. The topics addressed include: the FAA's organizational structure, FAA publications pertaining to maintenance, aviation maintenance procedures, the application of aviation maintenance concepts, and budgeting, cost controls, and cost reduction. Also considered are: training and professional development in aviation maintenance, safety and maintenance, electronic data processing, and aviation maintenance management problem areas. C.D.

**A86-21325**
**GENERAL AVIATION AND REGIONAL AIR TRAFFIC - COMPONENTS OF THE TRAFFIC SYSTEM, SYMPOSIUM, FRIEDRICHSHAFEN, WEST GERMANY, MARCH 28, 29, 1985, REPORTS [DIE ALLGEMEINE LUFTFAHRT UND REGIONALLUFTVERKEHR BESTANDTEILE DES VERKEHRSSYSTEMS, SYMPOSIUM, FRIEDRICHSHAFEN, WEST GERMANY, MARCH 28, 29, 1985, VORTRAEGE]**
Symposium sponsored by DGLR, DGON, and BMFT. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, 196 p. In German. No individual items are abstracted in this volume.

The airport system in the Federal Republic of Germany is considered, taking into account 11 international airports, 30 smaller airports, air traffic requirements, the importance of general aviation and regional air traffic for the economy, and the significance of smaller airlines that can provide cost-effective air transportation for regions and cities which cannot be profitably serviced by the big airliners of the large airlines. Attention is given to the role of the Lufthansa in the regional air traffic of West Germany, the regional air traffic from the point of view of the European Regional Airlines Organization (ERA), observations made in connection with regional air traffic, the effect of regional air traffic on the region in which the airport is located, observations made in an airport with respect to air traffic control, and requirements related to runways in case of instrument flight operations at regional airports. The political and economic significance of air traffic involving business aircraft is considered along with the availability of the Global Positioning System. G.R.

**A86-21894#**
**TOWARD AUTOMATED AIRFRAME ASSEMBLY**
W. H. REIMANN (USAF, Manufacturing Technology Div., Wright-Patterson AFB, OH) Aerospace America (ISSN 0740-722X), vol. 24, Jan. 1986, p. 44-46, 48.

The U.S. Air Force has been supporting research on flexible automated systems for airframe assembly over the course of several years. Attention is given to the use of two robots to inspect F-15 fighter airframe bulkheads, reducing the current 25-hr process in which 1100 measurements are conducted to a 2.5-hr one. Also noted is the robotic assembly of a microswitch from 17 parts that have been positioned randomly on a tray. Also sponsored are two programs on flexible assembly subsystems that are developing the technologies required by an Automated Assembly Center, such as flexible fixturing, part-location sensing, and temporary/permanent fastening of parts. O.C.

**A86-22128**
**EVOLUTION OF AIRCRAFT/AEROSPACE STRUCTURES AND MATERIALS SYMPOSIUM, DAYTON, OH, APRIL 24, 25, 1985, PROCEEDINGS**
Symposium sponsored by AIAA. Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, 137 p. For individual items see A86-22129 to A86-22144.

Various papers on the evolution of aircraft and aerospace structures and materials are presented. The topics addressed include: XB-70 structures and materials advances, structural evolution from B-58 to F-16, advanced composites in construction of the Beech Starship, structural and material considerations for advanced fighters, the evolution of reciprocating engines at Lycoming, aircraft design from the myth of make-do to Mach 3, and the Wright Brothers' experience in the evolution of aircraft design, structures and materials. Also considered are: evolution of the turbofan aircraft engine, X-15 high-temperature advanced structure, X-20 structures overview, ASSET program for technology development, Shuttle Orbiter airframe, airframe design to achieve minimum cost, superplastically formed-diffusion bonded titanium technology transition case study, transition of advanced materials and structures in single crystal blades, and composites technology transfer and transition. C.D.

**N86-16187*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**VORTEX WAKE ALLEVIATION STUDIES WITH A VARIABLE TWIST WING**
G. T. HOLBROOK, D. M. DUNHAM, and G. C. GREENE Nov. 1985 117 p refs
(NASA-TP-2442; L-15870; NAS 1.60:2442) Avail: NTIS HC A06/MF A01 CSCL 01B

Vortex wake alleviation studies were conducted in a wind tunnel and a water towing tank using a multisegmented wing model which provided controlled and measured variations in span load. Fourteen model configurations are tested at a Reynolds number of one million and a lift coefficient of 0.6 in the Langley 4- by 7-Meter Tunnel and the Hydronautics Ship Model Basin water tank at Hydronautics, Inc., Laurel, Md. Detailed measurements of span load and wake velocities at one semispan downstream correlate well with each other, with inviscid predictions of span load and wake roll up, and with peak trailing-wing rolling moments measured in the far wake. Average trailing-wing rolling moments are found to be an unreliable indicator of vortex wake intensity because vortex meander does not scale between test facilities and free-air conditions. A tapered-span-load configuration, which exhibits little or no drag penalty, is shown to offer significant downstream wake alleviation to a small trailing wing. The greater downstream wake alleviation achieved with the addition of spoilers to a flapped-wing configuration is shown to result directly from the high incremental drag and turbulence associated with the spoilers and not from the span load alteration they cause. Author

**N86-16188#** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

**AIR AND SPACE FLIGHT. DREAM AND FACTS [LUFT- UND RAUMFAHRT. TRAUM UND WIRKLICHKEIT]**

L. BOELKOW, K. VONGERSDORFF, and H. J. EBERT 1985 32 p In GERMAN Presented at the opening of the Air and Space Travel Hall of the Deutsches Museum, Munich, West Germany, 6 May 1984 and at Bayerischer Verdienstorden, 20 Jul. 1984

(MBB-FILM-382) Avail: NTIS HC A03/MF A01

The history of man's conquest of the air and space with hot air balloons, subsonic and hypersonic aircraft, helicopters and gliders as well as rockets, space shuttles, and manned space flights is reviewed. Progress in aircraft and space technology is discussed. Author (ESA)

**N86-16189#** Rijksluchtvaartdienst, The Hague (Netherlands).

**ACTIVITIES REPORT IN AERONAUTICS Annual Report, 1984 [JAARVERSLAG 1984]**

1984 62 p In DUTCH

Avail: NTIS HC A04/MF A01

The activities of the Dutch Civil Aeronautics Board (CAB) are reviewed. Air traffic control, airfields, air transportation, aviation security, aviation school, national aeronautics and astronautics museum, and national aeronautics and astronautics laboratory are presented. Regional services in Europe; an aviation accident law; Maastricht airport; and recognition of industries by the CAB are discussed. Author (ESA)

**N86-16190#** Societe Nationale Industrielle Aerospatiale, Suresnes (France). Lab. Central.

**PROBLEMS FOUND WHEN INTRODUCING NEW MATERIALS [PROBLEMES POSES PAR L'INTRODUCTION DES MATERIAUX NOUVEAUX]**

G. HILAIRE 29 Apr. 1985 34 p In FRENCH Presented at Journees de la Technologie 1984, Jonville, France, 5-6 Dec. 1984

(SNIAS-852-551-101; C-47-652-AC/GH-AT) Avail: NTIS HC A03/MF A01

Aircraft specifications and design problems are discussed. The parameters guiding the choice of new materials are analyzed. Organic matrix composite materials, carbon or glass, aluminum lithium alloys, titanium alloys and metallic matrix composites are examined. The effect of a new material on the aircraft life and maintenance and operation cost is discussed. Fatigue problems and lithium alloys are studied. Author (ESA)

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-19631#**

**AN EXPERIMENTAL INVESTIGATION OF AN AIRFOIL PITCHING AT MODERATE TO HIGH RATES TO LARGE ANGLES OF ATTACK**

G. M. GRAHAM and J. H. STRICKLAND (Texas Tech University, Lubbock) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p. Research supported by the Sandia National Laboratory. refs

(Contract F49620-82-C-0035)

(AIAA PAPER 86-0008)

Flow visualization data, surface pressure distributions, and load cell data were obtained from a NACA 0015 airfoil undergoing constant pitch motions over a wide range of nondimensional pitch rates. In each case, the motion began at 0 deg angle-of-attack, and terminated when the airfoil reached 90 deg angle-of-attack. It was found that lift and drag coefficient data could be correlated using simple trigonometric functions. These correlations in turn allow one to estimate lift and drag coefficients over the entire range of motion for any nondimensional pitching rate. Author

**A86-19633*#** Informatics General Corp., Palo Alto, Calif.

**UNSTEADY TRANSONICS OF A WING WITH TIP STORE**

G. P. GURUSWAMY (Informatics General Corp., Palo Alto, CA), P. M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA), and E. L. TU AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p. USAF-supported research. refs

(AIAA PAPER 86-0010)

The presence of tip stores influences both the aerodynamic and the aeroelastic performance of wings. Such effects are more pronounced in the transonic regime. In this study, a theoretical method is developed, for the first time, to compute unsteady transonics of oscillating wings with tip stores. The method is based on the small-disturbance, aerodynamic equations of motion from the potential-flow theory. To validate the method, subsonic and transonic aerodynamic computations are made for a lower-aspect-ratio wing, and they are compared with the available experimental data. Comparisons are favorable. The strong effects of the tip store on the transonic aerodynamics of the wing are also illustrated. The method developed in this steady can be used for transonic, aeroelastic computations of wings with tip stores. Author

**A86-19635#**

**OSCILLATING HOT-WIRE MEASUREMENTS ABOVE AN FX63-137 AIRFOIL**

W. S. SARIC (Arizona State University, Tempe) and J. D. CROUCH AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs

(Contract N00014-84-K-0093; N00014-85-K-0527)

(AIAA PAPER 86-0012)

A system is developed to allow measurement of both the mean and disturbance flow velocities in separated regions. An oscillation arm assembly is developed which provides a directional bias to the hot-wire probe, along with a linear step assembly, which steps the probe through the boundary layer. A series of velocity profiles are measured on the FX63-137 airfoil in the chord Reynolds number range of 150,000 to 300,000, at angles of attack of alpha = 12 deg and alpha = 14 deg. Data are presented on the size of the separation bubble and on the location of transition to turbulence. Author

**A86-19676*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NUMERICAL MODELING OF ROTOR FLOWS WITH A CONSERVATIVE FORM OF THE FULL-POTENTIAL EQUATIONS**

R. C. STRAWN (NASA, Ames Research Center, Moffett Field, CA) and F. X. CARADONNA (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(AIAA PAPER 86-0079)

A computer program has been developed to solve a three-dimensional conservative formulation of the full-potential equation. Its ability to solve transonic, unsteady rotor flows is demonstrated by comparison to forward flight non-lifting pressure data at low to moderate advance ratios. A 'split potential' formulation has been added to the code which incorporates known vorticity fields into the full-potential calculation. Using this methodology, rotor wake contributions have been incorporated into the computer code. Pressure results are presented for lifting rotors in hover. These results are compared to experimental data as well as to other predictions. Author

**A86-19693*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### THE COMPUTATION OF STEADY 3-D SEPARATED FLOWS OVER AERODYNAMIC BODIES AT INCIDENCE AND YAW

T. H. PULLIAM (NASA, Ames Research Center, Moffett Field, Stanford, CA) and D. PAN AIAA, Aerospace Sciences Meeting, 24th, Reno, NV. Jan. 6-9, 1986. 12 p. refs
(Contract NCA2-IR-745-404)
(AIAA PAPER 86-0109)

This paper describes the implementation of a general purpose 3-D NS code and its application to simulated 3-D separated vortical flows over aerodynamic bodies. The thin-layer Reynolds-averaged NS equations are solved by an implicit approximate factorization scheme. The pencil data structure enables the code to run on very fine grids using only limited incore memories. Solutions of a low subsonic flow over an inclined ellipsoid are compared with experimental data to validate the code. Transonic flows over a yawed elliptical wing at incidence are computed and separations occurred at different yaw angles are discussed. Author

**A86-19696#**

### INFLUENCE OF EXCITATION ON COHERENT STRUCTURES IN REATTACHING TURBULENT SHEAR LAYERS

F. W. ROOS and J. T. KEGELMAN (McDonnell Douglas Research Laboratories, St. Louis, MO) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 86-0112)

A series of experiments was performed in the reattaching turbulent shear layer produced by flow over a backward-facing, two-dimensional step. Gentle excitation of the shear layer by an oscillating flap at the step lip proved to be highly effective in regularizing and enhancing the formation and development of vortical structures in the reattaching flow. Effects of variations in excitation amplitude and frequency were defined. An excitation-frequency-sensitive reduction in reattachment length was identified with the process of vortical-structure coalescence in the shear layer upstream of reattachment. Shear-layer excitation was shown to increase the intensity of reattachment-wall pressure fluctuations in all cases, regardless of the reattachment-length effect. Subharmonic phase-modulation of the shear-layer excitation was demonstrated to be effective in regularizing the vortex-merging process in the reattaching shear layer. Author

**A86-19697#**

### COMPUTATION OF DYNAMIC STALL OF NACA0012 AIRFOIL BY BLOCK PENTADIAGONAL MATRIX SCHEME

Y. SHIDA, H. TAKAMI, K. KUWAHARA (Tokyo, University, Japan), and K. ONO (Nihon University, Tokyo, Japan) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs
(AIAA PAPER 86-0116)

The flow field around an oscillating NACA0012 airfoil in pitch at 0.25 chord is analyzed by solving the two-dimensional compressible Navier-Stokes equations. A block pentadiagonal matrix scheme based on the approximate factorization method is adopted. Two kinds of mesh, 161 x 40 and 321 x 80, are used. In the case of coarse mesh, lift stall is captured. In the case of fine mesh, not only lift stall but also restoration process of the lift coefficient in the downstroke is captured. The process of the beginning of separation at stall stage is intensively studied. Author

**A86-19698#**

### LIFT-CURVE CHARACTERISTICS FOR AN AIRFOIL PITCHING AT CONSTANT RATE

E. J. JUMPER (USAF, Institute of Technology, Wright-Patterson AFB, OH), S. J. SCHRECK (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and R. L. DIMMICK AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs
(AIAA PAPER 86-0117)

Daley and Jumper (1984) have conducted an experimental study of dynamic stall for an airfoil pitching at constant rates. The present paper provides a report on a systematic study of the dynamic-stall event in the case of an airfoil which pitches at a constant rate. A total of 100 dynamic-stall data runs were made at five tunnel speeds in the range of flow velocities from 26 to 48 ft/s. At each tunnel speed four pitch rates were used. Attention is given to details regarding the experimental approach, the obtained results, lift-curve characteristics, preseparation characteristics, drag and moment characteristics, and general comments. It is believed that the results reported provide insight into the mechanisms at work in the dynamic-stall process. It is emphasized that different mechanisms are at work at different points in the dynamic-stall event. G.R.

**A86-19699#**

### VORTICES PRODUCED BY AIR PULSE INJECTION FROM THE SURFACE OF AN OSCILLATING AIRFOIL

M. C. ROBINSON and M. W. LUTTGES (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p. refs
(Contract AF-AFOSR-81-0037)
(AIAA PAPER 86-0118)

High rates of vortex production are not consistent with the airfoil oscillation rates needed to match realistic, higher Reynolds numbers. Thus, alternative mechanisms must be evolved for the control and generation of large scale vortices which can yield significant amounts of lift enhancement. The present study is concerned with a noval means for producing large scale vortices over a dynamically pitching airfoil. A pulse of air is delivered during each cycle of the sinusoidal pitch oscillation. The pulse produces a brief stream of air arising from a span oriented slot located at 0.1c parallel to the leading edge. Experiments were conducted on an NACA 0015 airfoil with six inch chord in a subsonic, low turbulence wind tunnel. Attention is given to experimental details, unsteady flow visualization, the development of pulse vortices, and hot wire anemometry of flow with and without air pulse injection. G.R.

**A86-19700#**

### FLUID DYNAMICS OF CYLINDER RESPONSE TO KARMAN VORTEX SHEDDING

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs
(AIAA PAPER 86-0119)

The fluid mechanics of cylinder response to Karman vortex shedding are composed of three district flow phenomena: (1) the vortex wake formation, (2) the coupling between flow separation and body motion, and (3) the interaction between shed vortices and the body cross-section. Analysis of available experimental results for circular and rectangular cross-section cylinders shows that, for small amplitudes, (1) is the dominating flow mechanism, and the cylinder response is of the resonant type. However, when the amplitude exceeds a few percent of the cylinder crossflow dimension, the dominating flow mechanism is (2), and the cylinder response changes from the resonant to the self-excited type typical for systems with nonlinear negative damping. Flow mechanism (3) appears only to be important if the cross-section has a suitable chordwise extent, as in the case of the rectangular cross-sections. Author

**A86-19702#**

### STEADY AND UNSTEADY FULL POTENTIAL CALCULATION FOR LARGE AND SMALL ASPECT RATIO SUPERCRITICAL WINGS

S. Y. RUO, J. B. MALONE (Lockheed Georgia Co., Marietta, GA), and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs
(AIAA PAPER 86-0122)

A numerical method which solves the three-dimensional full-potential equation by a strongly implicit, approximate factorization algorithm is used to analyze the flow over a high and a low aspect ratio wing. Steady and unsteady flow analyses are respectively obtained by relaxation and time-accurate marching.

Numerical results are compared with the available experimental data. Author

**A86-19730*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### SUMMARY OF A HIGH SUBSONIC FORCE/PRESSURE EXPERIMENT FOR 58 DEG CAMBERED/TWISTED THICK DELTA WINGS

J. CHU and J. E. LAMAR (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(AIAA PAPER 86-0169)

This paper summarizes the results of a force, moment, and pressure experiment involving six thick, cambered and twisted, delta wings with 58 deg leading-edge sweep. This experiment was conducted in the NASA Langley 7- by 10-foot High-Speed Tunnel at Mach numbers of 0.75, 0.80, and 0.83. The design goal was a configuration which was self-trimming at a lift coefficient of 0.25 and Mach number of 0.80. Although the design goal was not met, the configuration which came closest and which had the best overall performance was selected for further study. Wing surface pressure data and limited surface oil flow data for this configuration are presented to show the extent of attached flow at the design point. For selected cases, inviscid solutions from vortex lattice method/suction analogy, PAN AIR, FLO-28, and FLO-57 are compared with the experimental force, moment, and pressure data. Author

**A86-19731#**

### ACOUSTIC AND TURBULENCE INFLUENCES ON STALL HYSTERESIS

J. F. MARCHMAN, III, V. SUMANTRAN, and C. G. SCHAEFER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs

(Contract N0014-84-K-0093)

(AIAA PAPER 86-0170)

The results of past research on the low Reynolds number aerodynamic behavior of the Wortmann airfoil have revealed differences in data taken at different facilities. A study was conducted to determine the extent to which wind tunnel turbulence and acoustic disturbances may be responsible for differences in test results in low Reynolds number flows. Results showed that increases in turbulence can substantially reduce the well known low Reynolds number stall hysteresis effect and can even eliminate the hysteresis loop. Acoustic disturbances of the proper frequency and level can produce similar effects and may produce even more substantial alteration of test results than turbulence. Users of low Reynolds number aerodynamic data and designers of aircraft for this flight regime should be sure that the data they use has not been prejudiced by the turbulence and noise effects found in this research. Author

**A86-19753#**

### UNSTEADY THREE-DIMENSIONAL SIMULATIONS OF A VTOL UPWASH FOUNTAIN

R. E. CHILDS and D. NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs

(Contract F49620-85-C-0055)

(AIAA PAPER 86-0212)

Numerical simulations of a planar turbulent wall jet and a planar VTOL upwash fountain have been performed. These are three-dimensional simulations which resolve large scale unsteady motions in the flows. The wall jet simulation shows good agreement with experimental data and is presented to verify the simulation methodology. Simulation of the upwash fountain predicts elevated shear stress and a half-velocity width spreading rate of 33 percent which agrees well with experiment. Turbulence mechanisms which contribute to the enhanced spreading rate are examined. Author

**A86-19774#**

### SPANWISE TURBULENCE EFFECTS ON AIRCRAFT RESPONSE

E. A. RINGNES, D. W. CAMP, and W. FROST (FWG Associates, Inc., Tullahoma, TN) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 5 p.

(AIAA PAPER 86-0255)

Turbulence across the span of a wing influences the dynamic response of an aircraft. In this paper, flight data collected with the NASA B-57B research aircraft as part of the Gust Gradient Program is utilized to investigate spanwise turbulence. The theoretical modeling is set up to calculate the aerodynamic moments and forces developed due to a distribution of turbulence. This is made possible by the three independent records of both angle of attack and airspeed from the aircraft nose and each wing tip. The magnitude of these moments and forces, called the effects of spanwise turbulence, are presented. Furthermore, as a second part of the study, the spanwise turbulence effects are incorporated into a six-degrees-of-freedom flight simulation carried out on a Pixel computer. The results from the simulation show significant influences from spanwise turbulence effects. As expected, the roll mode of the B-57B dynamic response is most strongly excited. Author

**A86-19789#**

### NUMERICAL SIMULATION OF IMPINGING JETS

M. H. RIZK and S. MENON (Flow Research Co., Kent, WA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 15 p. refs

(Contract F49620-84-C-0027)

(AIAA PAPER 86-0279)

Direct numerical simulation using both the three-dimensional and two-dimensional, time-dependent Navier-Stokes equations is used to investigate V/STOL jet-induced interactions. The objective of this numerical simulation is to compute accurately the details of the flow field and to achieve a better understanding of the physics of the flow, including the role of initial turbulence in the jet, the influence of forward motion on hover aerodynamics, and the characteristics of the collision zone and the fountain. Preliminary results are presented. Author

**A86-19807*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### DESIGN OF A NATURAL LAMINAR FLOW WING FOR A TRANSONIC CORPORATE TRANSPORT

R. L. CAMPBELL, E. G. WAGGONER, and P. S. PHILLIPS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(AIAA PAPER 86-0314)

Two- and three-dimensional computational methods were used to design a wing for a transonic corporate transport that had significant runs of laminar flow on both upper and lower wing surfaces at the cruise condition. The airfoil was derived from a low-speed laminar-flow section. The contour was systematically modified based on results from a two-dimensional transonic code to give favorable pressure gradients to 50-percent chord on the upper surface and 65-percent chord on the lower surface. Three-dimensional transonic codes were used to determine the wing twist and to evaluate the aerodynamic characteristics of the complete configuration at various flight conditions. A leading-edge modification for improved stall characteristics was also designed. The theoretical pressure distributions for the final airfoil correlated well with results from wind-tunnel tests. Author

**A86-19808*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AN EVALUATION OF LEADING-EDGE FLAP PERFORMANCE ON DELTA AND DOUBLE-DELTA WINGS AT SUPERSONIC SPEEDS

P. F. COVELL, D. S. MILLER, and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0315)

The aerodynamic performance of leading-edge flaps on three delta double-delta wing planforms having aspect ratios of 1.75, 2.11, and 2.50, have been investigated experimentally. The wings were mounted on a generic fuselage without an inlet canopy, or a vertical tail. The Mach numbers of the flow over the wings were 1.60, 1.90 and 2.16. A primary set of full-span leading-edge flaps with similar root and tip chords were tested on each wing, and several alternate flap planforms were tested on the aspect ratio 1.75 wings. It is found that all leading edge geometries were effective in reducing drag lifting over the range of wing aspect ratios and Mach numbers tested. Greater flap performance was obtained when primary flaps were applied to the delta planform. In general, the primary flap geometry yielded better performance than the alternative geometries tested. Flow visualization techniques were found to be useful for identifying the beneficial effects of leading-edge flap deflection on flow separation as well as fuselage interference effects. Black and white photographs of the delta and double-delta planforms are provided. I.H.

**A86-19809*#** Vigyan Research Associates, Inc., Hampton, Va.

### SHAPING OF AIRPLANE FUSELAGES FOR MINIMUM DRAG

S. S. DODBELE, C. P. VAN DAM (Vigyan Research Associates, Inc., Hampton, VA), B. J. HOLMES (NASA, Langley Research Center, Hampton, VA), and P. M. H. W. VIJGEN AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs
(Contract NAG1-345; NAS1-17926)
(AIAA PAPER 86-0316)

The VSAERO surface panel method is employed to investigate fuselage shapes which can enhance the natural laminar flow (NLF) characteristics. The study is performed at cruise Re which are relevant to commuter, transport, and business aircraft. The technique is based on piecewise constant doublet and source singularities and takes into account the effects of compressibility. Inviscid pressure distributions were generated for five configurations to aid in the search for an optimized NLF body shape as a function of the transition locations and the drag coefficients. Granville's transition criteria are incorporated into the calculations to yield shapes with longer runs of laminar flow and reduced drag. In comparison with other transition prediction methods, the method described is shown to have significantly higher valicity for making three-dimensional transition predictions. M.S.K.

**A86-19810*#** Missouri Univ., Rolla.

### INVESTIGATION OF CHORD RATIO, STAGGER, DECALAGE ANGLE, AND FLAP ANGLE FOR DUAL WING CONFIGURATIONS

B. P. SELBERG (Missouri-Rolla, University, Rolla) and G. D. VINCENT AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs
(Contract NAG1-26)
(AIAA PAPER 86-0317)

Aerodynamical closely coupled dual wing configurations of unequal chords are investigated for medium speed general aviation applications. Vortex panel and momentum boundary layer analysis are utilized for the two-dimensional predictions. A multi-surface vortex lattice method is used for the three-dimensional predictions. In the process of searching for the highest lift to drag ratio upper airfoil to lower airfoil chord ratios, both greater and less than one, are investigated in terms of stagger, decalage angle, and gap. With the optimum chord ratio, at the optimum stagger and gap, proper spanwise decalage distribution is shown to yield the lowest two dimensional drag results. Various wing taper ratios and wing twists are investigated to increase wing efficiency. Comparisons are made between optimized dual and optimized single wing configurations both with the same fuselage, stabilator surfaces, engines, payload, and fuel. The dual wing configuration is shown to have significantly less drag and hence longer range than the conventional single wing configuration. Author

**A86-19817*#** Notre Dame Univ., Ind.

### VISUALIZATION AND FLOW SURVEYS OF THE LEADING EDGE VORTEX STRUCTURE ON DELTA WING PLANFORMS

F. M. PAYNE, T. T. NG, R. C. NELSON (Notre Dame, University, IN), and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. Research supported by the University of Notre Dame. refs
(Contract NAG2-258)
(AIAA PAPER 86-0330)

In the present experimental investigation of thin delta wing vortex breakdown, for the cases of sweep angles of 70, 75, 80, and 85 deg, and smoke flow visualization/laser light sheet technique is used to obtain cross sectional views of the leading edge vortices as they break down. A combination of lateral and longitudinal cross sectional views furnishes data on the three-dimensional character of the vortex before, during, and after breakdown. Velocity measurements conducted with a laser Doppler anemometer on the 70 deg sweep delta, at 30 deg angle-of-attack, indicate that when breakdown occurs the core flow is transformed from a jet-like to a wake-like flow. O.C.

**A86-19833#**

### VORTEX-AIRFOIL INTERACTION TESTS

D. D. SEATH and D. R. WILSON (Texas, University, Arlington) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 5 p.
(Contract DAAG29-84-K-0131)
(AIAA PAPER 86-0354)

Low-speed wind tunnel tests were conducted of a pressure-tapped wing model that spanned the test section and was located downstream of a half-wing model that generated a tip vortex. Tests of this perpendicular vortex-airfoil interaction showed that the vortex caused a substantial change in the pressure distribution of the downstream wing and also exhibited a spanwise drift as it passed over the wing. The [illegible] drift was in the same direction as the spanwise component of the induced flow at the wing surface, and may be attributed to an image effect, similar to the drifting apart of a wing's trailing vortices as they approach the ground. Author

**A86-19855#**

### EVALUATION OF METHODS FOR PREDICTING COMPLEX AIRCRAFT FLOWFIELDS

A. CENKO (Hofstra University, Hempstead, NY) and F. TESSITORE (Grumman Aerospace Corp., Bethpage, NY) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0396)

Reliable methods for predicting external aircraft flowfields are required for airframe/inlet and aircraft/store integrations, as well as for predicting store trajectories. Several analytic techniques exist which, under certain conditions, can predict the flowfield of complex aircraft configurations. This paper evaluates three of these - the PAN AIR panel method, the Boppe Transonic small disturbance code, and the Grumman TFM technique - and compares them to each other as well as to experimental data and other codes. Author

**A86-19870#**

### THREE-DIMENSIONAL BODY-FITTING GRID SYSTEM FOR A COMPLETE AIRCRAFT

S. J. SCHERR and J. S. SHANG (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0428)

A three-dimensional body-fitted grid system is generated for use in solving the Reynolds-averaged Navier-Stokes equations of the flow field about a complete aircraft. A single-block multiple-plane mesh is constructed by juxtaposition of two-dimensional cross-sections. A composite grid is used to ensure that the mesh is boundary conformal and orthogonal at the vehicle surface. The mesh singularity inherent in a body-conformal system at the nose of the vehicle is removed by use of analytic continuation and reflection properties. Author

**A86-19871*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THREE-DIMENSIONAL ELLIPTIC GRID GENERATION ABOUT FIGHTER AIRCRAFT FOR ZONAL FINITE-DIFFERENCE COMPUTATIONS**

R. L. SORENSON (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 8 p. refs

(AIAA PAPER 86-0429)

An elliptic grid-generation method for finite-difference computations about complex aerodynamic configurations is developed. A zonal approach is used, which involves first making a coarse global grid filling the entire physical domain and then subdividing regions of that grid to make the individual zone grids. The details of the grid-generation method are presented along with results of the present application, a wing-body configuration based on the F-16 fighter aircraft. Author

**A86-19873*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DEFINITION AND VERIFICATION OF A COMPLEX AIRCRAFT FOR AERODYNAMIC CALCULATIONS**

T. A. EDWARDS (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(AIAA PAPER 86-0431)

Techniques are reviewed which are of value in CAD/CAM CFD studies of the geometries of new fighter aircraft. In order to refine the computations of the flows to take advantage of the computing power available from supercomputers, it is often necessary to interpolate the geometry of the mesh selected for the numerical analysis of the aircraft shape. Interpolating the geometry permits a higher level of detail in calculations of the flow past specific regions of a design. A microprocessor-based mathematics engine is described for fast image manipulation and rotation to verify that the interpolated geometry will correspond to the design geometry in order to ensure that the flow calculations will remain valid through the interpolation. Applications of the image manipulation system to verify geometrical representations with wire-frame and shaded-surface images are described. M.S.K.

**A86-19880*#** Massachusetts Inst. of Tech., Cambridge.

**COMPARISON OF COMPUTATIONS AND EXPERIMENTAL DATA FOR LEADING EDGE VORTICES - EFFECTS OF YAW AND VORTEX FLAPS**

E. M. MURMAN, K. G. POWELL (MIT, Cambridge, MA), D. S. MILLER, and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs

(Contract NAG1-358)

(AIAA PAPER 86-0439)

Computations are presented using the conical Euler equations for swept delta wings with leading edge vortices. All the wings have sharp leading edges swept at 75 degrees to the freestream. In addition to an idealized flat plate model, geometrical features also included are thickness, centerbody, and two vortex flaps. Freestream Mach numbers of 1.7 to 2.8, angles of attack of 10 and 12 degrees, and angles of yaw of 0 and 8 degrees are considered. The computations are compared with pitot pressure traverses for one case. Other calculations are compared with pitot pressure traverses for one case. Other calculations are compared with surface pressure data and vapor screen pictures recently obtained at NASA Langley Research Center. The comparisons indicate that the dominant features of these flows are adequately modeled by the Euler equations, but viscous models are needed for the surface boundary layer and secondary separations. Author

**A86-19892#**

**A NUMERICAL SOLUTION OF THE DOWNWASH ASSOCIATED WITH A BLOWN-FLAP SYSTEM**

E. LOTH and B. W. MCCORMICK (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs

(Contract N62269-84-C-0437)

(AIAA PAPER 86-0473)

For blown flap aircraft, large downwashes typically occur downstream of the wing due to the high downward momentum of the lifting jet. To determine the velocities induced by the wing and jet flap circulation, a 3-D nonlinear finite element model has been developed which can predict downwash angles at any desired location. Vortex lattices positioned on the wing, flap, and thin jet sheet provide vortex filaments and control points to satisfy kinematic and dynamic boundary conditions. To simplify the mixed-boundary value problem and to reduce computer run time, the roll up of the wake in the spanwise direction has been neglected. In addition, the spanwise distribution of circulation in the wake is assumed to be elliptic in form, a reasonably fast and stable iterative method was used which allowed a self-consistent wake path to be found. Predicted downwash and lift coefficients generally agree with experimental values for various test conditions, but further improvements such as fuselage modeling would enhance the accuracy of the model. Author

**A86-19893*#** Nielsen Engineering and Research, Inc., Mountain View, Calif.

**LIFT AUGMENTATION VIA SPANWISE TIP BLOWING - A NUMERICAL STUDY**

R. E. CHILDS (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. NASA-supported research.

(Contract F33615-83-C-3033)

(AIAA PAPER 86-0474)

Numerical simulations of a low aspect ratio wing with and without a spanwise directed jet issuing from the wing tip have been performed. The results show that the tip vortex is displaced outward and upward by the blowing. This gives rise to a local lift augmentation mechanism, vortex lift caused by the vortex core being above the wing, and a global mechanism, the reduction of induced velocities due to greater apparent spin. Author

**A86-19897*#** Ohio State Univ., Columbus.

**AERODYNAMIC MEASUREMENTS OF AN AIRFOIL WITH SIMULATED GLAZE ICE**

M. B. BRAGG and W. J. COIRIER (Ohio State University, Columbus) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. NASA-supported research. refs

(AIAA PAPER 86-0484)

An experimental study has been conducted in the OSU subsonic tunnel to measure the detailed aerodynamic characteristics of an airfoil with simulated glaze ice. A special model was built with interchangeable leading edges to be used in this study. One leading edge is that of a NACA 0012, while the other is a simulation of a glaze ice accretion measured in the NACA Lewis Icing Research Tunnel. The model was instrumented with a dense distribution of surface pressure taps to provide excellent detail around the ice shapes and reattachment point. A traversing total pressure probe was used to document the boundary layer characteristics on the NACA 0012 section. The ice shape caused a severe lift and drag penalty, reducing the maximum lift by over 50 percent and causing a 300 percent increase in drag. Surface pressure distributions revealed a large lower surface separation in addition to the expected large upper surface separation. Author

**A86-19906#**

**CONFORMAL MAPPING AS AN AID IN GRID GENERATION FOR COMPLEX THREE-DIMENSIONAL CONFIGURATIONS**

N. D. HALSEY (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. Research sponsored by the McDonnell Douglas Independent Research and Development Program. refs

(AIAA PAPER 86-0497)

Conformal mapping is a very useful, but under-exploited, tool in the construction of body-fitted finite-difference (or finite-volume) grids for complex three-dimensional configurations. It has been used frequently for many two-dimensional problems and, to a lesser extent, for simple three-dimensional configurations, such as isolated wings or nacelles and wing/body combinations. This paper describes applications of conformal mapping in generating grids about three-dimensional nacelles with and without other aircraft components in close proximity. In the most complicated case considered, a grid is generated about an aft-fuselage-mounted nacelle/pylon configuration. Author

**A86-19922#**

**PRACTICAL APPLICATIONS OF NEW LU-ADI SCHEME FOR THE THREE-DIMENSIONAL NAVIER-STOKES COMPUTATION OF TRANSONIC VISCOUS FLOWS**

K. FUJII (National Aerospace Laboratory, Chofu, Japan) and S. OBAYASHI (Tokyo, University, Japan) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs

(AIAA PAPER 86-0513)

The new LU-ADI factorization algorithm for the three-dimensional Navier-Stokes computations is developed by using the diagonally dominant LU factorization. The applications are done for a practical wing shape designed for transonic transport aircraft. Computations are carried out for several angle-of-attack cases, including the design point and the buffet limit. The computed surface pressure distributions agree with the experiment, in spite of the complicated wing geometry. The C(L)-alpha curve is plotted, with good agreement with the experiment. The computation for each case takes only about an hour and a half with the aid of a supercomputer. The preliminary computation is done for the wing-body combination, and the result is quite reasonable and promising. These results indicate the possibility of the three-dimensional Navier-Stokes code for the flow field simulations over an entire aircraft configuration. Author

**A86-19949*#** Scientific Research Associates, Inc., Glastonbury, Conn.

**A THREE-DIMENSIONAL VISCOUS FLOW ANALYSIS FOR THE HELICOPTER TIP VORTEX GENERATION PROCESS ABOUT SQUARE AND ROUND TIPPED BLADES**

S.-J. LIN, R. LEVY, and S. J. SHAMROTH (Scientific Research Associates, Inc., Glastonbury, CT) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p. Previously announced in STAR as N85-34114. refs

(Contract NAS1-14904)

(AIAA PAPER 86-0560)

The tip vortex flow field occurring in the vicinity of the tip region of a helicopter rotor blade is a very complicated three-dimensional, viscous flow phenomenon. The details of the flow in the tip region can have a major effect in determining the generated rotor noise and can significantly effect the performance and dynamic loading of the rotor blade. The three-dimensional viscous subsonic tip vortex generation processes is investigated by a numerical procedure which allows spatial forward-marching integration, utilizing flow approximations from the velocity-decomposition approach of Briley and McDonald. The approach has been applied to compute the laminar and turbulent tip vortex flows for a constant thickness slab airfoil with a square tip, a constant thickness slab airfoil with a half round tip and a NACA 0012 airfoil with a half round tip. The basic mechanism of the tip vortex generation process as well as the prediction of vortex appearance, strength and secondary flow shown by the calculations are in qualitative agreement with experimental results. Author

**A86-19951#**

**VORTEX ROLL-UP FOR AN ELLIPTICALLY-LOADED WING AT MODERATELY LOW REYNOLDS NUMBERS**

H. HIGUCHI, J. C. QUADRELLI, and C. FARELL (Minnesota, University, Minneapolis) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs

(AIAA PAPER 86-0562)

An experimental investigation of tip-vortex roll-up was undertaken at moderately low Reynolds numbers, for an elliptically-loaded foil with a NACA 66(2)-415 section. Flow visualizations and laser Doppler velocimetry measurements were carried out to examine the flow in the vortex core and the tangential velocity distributions around the core. Separation was observed on both sides of the foil for Reynolds numbers up to 500,000. The observed changes in the location of separation and reattachment with angle of attack and Reynolds number, were adequately predicted by laminar boundary layer calculations. Axial and tangential velocity profile measurements were made at Reynolds numbers up to about 50,000. The vortex core radius was found to grow with increasing angle of attack, increasing downstream distance, and decreasing Reynolds number. A comparison of the experimentally determined velocity distributions and core sizes, with the predictions of inviscid, laminar, and turbulent vortex models, is presented. Author

**A86-19964#**

**A PREDICTIVE TECHNIQUE FOR DETERMINING STORE MOTION AFTER RELEASE FROM A CARRIER VEHICLE AT SUPERSONIC SPEEDS**

A. J. CULOTTA (Martin Marietta Corp., Orlando, FL) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs

(AIAA PAPER 86-0586)

A new technique has been devised for predicting the motion of a single store released from a supersonic carrier vehicle. The technique involves the simplified determination of store aerodynamics and 3-DOF motion in the carrier vehicle's flow field as modified by expansion fans and shock waves arising from open bays or surface recesses. Determination of these flow field features is assisted through flow visualization by means of low cost water table hydraulic analog. Technique verification was accomplished using M = 2, 3, and 4 grid survey and captive trajectory wind tunnel data and is applicable to both internally and conformally carried stores. Comparisons between computer predictions and experimental normal force and moment coefficients and pitch angle during separation show excellent agreement. For internally carried stores, computational results dramatically illustrate the dependence of store motion on various factors, such as, the carrier vehicle's bay pressure, strength of the carrier vehicle's bow show wave, initial ejection rates and accelerations and store aerodynamics. Technique limitations center around the means by which store aerodynamics are computed in a nonuniform flow field and the ability to define bay pressure during the separation events. This later limitation does not exist for conformally carried stores. Author

**A86-19966*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EVALUATION OF AN AERODYNAMIC-LO[illegible] PREDICTION METHOD ON A STOL FIGHTER CONFIGURATION**

J. KATZ (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 18 p. Previously announced in STAR as N86-10015. refs

(AIAA PAPER 86-0590)

A three-dimensional panel method was used to compute the aerodynamic loads on a large-scale, powered wind tunnel model. The size of the computation grid was selected such that turnaround times, on present computers remained satisfactory. With this constraint, the STOL aircraft configuration was modeled and the capabilities and limitations of the prediction method were investigated. After this study, a similar numerical model was established for a forward-swept-wing aircraft configuration which is planned for large-scale, low-speed testing. The resulting aerodynamic-load predictions are discussed and will be utilized, together with the future experimental results, to obtain a broader validation of this method as well as to reduce the necessary size of the matrix of the test parameters. Author

**A86-19971*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**THE CRITICAL ROLE OF COMPUTATIONAL FLUID DYNAMICS IN ROTARY-WING AERODYNAMICS**
S. S. DAVIS and I.-C. CHANG (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 25 p. refs
(AIAA PAPER 86-0336)

The field of helicopter rotor aerodynamics is basically the study of unsteady aerodynamic flows in a rotating and translating coordinate system. Current trends in this field are briefly reviewed by examining recent advances in lifting-surface theory, wake modeling, panel methods, and finite-difference models. Examples are used to illustrate selected current methods and some indications of promising future directions are highlighted. Author

**A86-20124**
**AIRCRAFT VISCOUS DRAG REDUCTION TECHNOLOGY**
A. S. W. THOMAS (Lockheed-Georgia Co., Marietta, GA) Lockheed Horizons, Oct. 1985, p. 22-32.

An evaluation is made of the performance improvement prospects that accrue to viscous drag reduction in subsonic aircraft through laminar flow control (LFC), with attention to the development status of the requisite technology. Major system types currently under consideration are aerodynamic section tailoring to yield sustained natural laminar flow, the use of active skin suction through small holes to laminarize turbulent boundary layers, skin cooling by cryogenic liquids such as liquid hydrogen fuel, and longitudal, triangular section skin surface microgroovings called 'riblets'. Existing aircraft are noted to be amenable to LFC efficiency improvements through the judicious addition of strakes and winglets that modify vortex flows shed (respectively) by fuselage afterbodies and wings. Novel, low turbulence aircraft configurations for future development are presented. O.C.

**A86-20156*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**MODELING AERODYNAMIC RESPONSES TO AIRCRAFT MANEUVERS - A NUMERICAL VALIDATION**
J. KATZ and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 19-25. Previously cited in issue 20, p. 2847, Accession no. A84-42335. refs

**A86-20159*#** Lockheed-Georgia Co., Marietta.
**NUMERICAL SIMULATION OF THE TRANSONIC FLOWFIELD FOR WING/NACELLE CONFIGURATIONS**
E. H. ATTA and J. VADYAK (Lockheed-Georgia Co., Advanced Flight Sciences Dept., Marietta, GA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 39-46. Research sponsored by the Lockheed Independent Research and Development Program. Previously cited in issue 03, p. 254, Accession no. A85-13964. refs
(Contract NAS2-11285)

**A86-20164*#** Ohio State Univ., Columbus.
**AIRFOIL AERODYNAMICS IN ICING CONDITIONS**
M. B. BRAGG, G. M. GREGOREK, and J. D. LEE (Ohio State University, Columbus) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 76-81. NASA-supported research. refs

Methods of analyzing and experimentally measuring the effect of ice accretion on airfoil sections are presented. Empirical and analytical methods for predicting airfoil performance degradation due to ice are discussed. Ice simulation techniques for aerodynamic testing are presented and compared to data with actual ice accretions. The results show that simulation techniques to imitate the effect of ice on airfoil performance work well in most cases. Comparisons between predicted and measured airfoil performance with ice accretions are presented. For rime ice cases, the predictions compared well with experiments; but for glaze ice, a need for improved methods are seen. Author

**A86-20939**
**EULER SOLVERS AS AN ANALYSIS TOOL FOR AIRCRAFT AERODYNAMICS**
W. SCHMIDT (Dornier GmbH, Friedrichshafen, West Germany) and A. JAMESON (Princeton University, NJ) IN: Advances in computational transonics . Swansea, Wales, Pineridge Press, 1985, p. 371-404. refs

The present chapter is concerned with numerical techniques for solving hyperbolic systems of partial differential equations, taking into account the solution of the Euler equations. It is pointed out, however, that the presented algorithms have been successfully applied also to the Navier Stokes equations. The governing set of differential equations is discussed, giving attention to time-dependent Euler equations, transformed equations, the finite volume approach, and relations at discontinuities. Aspects of numerical discretization are also explored. Central space approximations are considered along with dissipative terms, time stepping schemes, boundary conditions, and Kutta conditions for lifting flows. Other topics studied are related to convergence acceleration, two-dimensional flows, and three-dimensional flows. G.R.

**A86-20946*** California Univ., Los Angeles.
**SHOCK MODELLING IN TRANSONIC AND SUPERSONIC FLOW**
S. OSHER (California, University, Los Angeles) IN: Advances in computational transonics . Swansea, Wales, Pineridge Press, 1985, p. 607-643. refs
(Contract NSF MCS-82-00788; DAAG29-82-K-0090; NAG1-270; NAG1-273)

Numerical simulation studies of problems in transonic flow are conducted in connection with the design of aircraft flying near the speed of sound, while recently there has also been a great deal of interest in supersonic and hypersonic flow calculations. Three important models for inviscid compressible gasdynamics are utilized in the study of these flow problems, taking into account the transonic small disturbance equation (TSD), the transonic full potential equation (FP), and the full Euler equations for compressible gasdynamics (EU). The present paper has the objective to provide a description of shock capturing methods recently developed for each model. The design principles behind the algorithms are also examined, giving attention to consistency, conservative form, monotone and sharp discrete shocks, and a bound on the variation, which prevents spurious oscillations. G.R.

**A86-20953*** Boeing Military Airplane Development, Seattle, Wash.
**A TRANSONIC RECTANGULAR GRID EMBEDDED PANEL METHOD**
F. T. JOHNSON, J. E. BUSSOLETTI, A. C. WOO (Boeing Military Airplane Co., Seattle, WA), and D. P. YOUNG (Boeing Computer Services Co., Tukwila, WA) IN: Advances in computational transonics . Swansea, Wales, Pineridge Press, 1985, p. 835-874. refs
(Contract NAS2-9830)

In this chapter, a description is given of a nonstandard method which has the ultimate goal to provide a routine solution of transonic flow problems about large, complex configurations. For a number of reasons, it is difficult to extend standard methods to the solution of flows about complicated configurations. According to the particular approach of the considered nonstandard method, in the process of solving for linear potential flow via panel methods, a flow everwhere in space is created, taking into account the interior of the aircraft as well as the external flowfield of interest. Attention is given to the solution of flow problems without interior boundaries, the treatment of interior boundaries, and areas of current and future research. G.R.

**A86-21033**

**THE NUMERICAL SOLUTION OF THE COMPRESSIBLE VISCOUS FLOW FIELD ABOUT A COMPLETE AIRCRAFT IN FLIGHT**

R. W. MACCORMACK (Washington, University, Seattle) IN: Computational methods in viscous flows . Swansea, Wales, Pineridge Press, 1984, p. 225-254. refs
(Contract AF-AFOSR-83-0057)

Estimates made by Chapman (1979) of the number of mesh points and computer memory required to calculate the viscous flow field about a complete aircraft at flight Reynolds number are reviewed, and it is noted that the required computer capability will become available in the near future The problems associated with the fitting of a mesh around an aircraft and the numerical procedures required for such a flow calculation are examined. It is argued that the Reynolds-averaged Navier-Stokes equations can be solved about a complete aircraft at cruise conditions with the coming computer resources with the same degree of accuracy and cost as present high Reynolds number calculations for flow past relatively simple aerodynamic shapes. V.L.

**A86-21345**

**A SOLUTION TO THE PROBLEM OF FLOW PAST WINGS WITH ALLOWANCE FOR FLOW SEPARATION ON THE BASIS OF A SYSTEM OF EULER EQUATIONS [RESHENIE ZADACHI OBTEKANIIA KRYL'EV S UCHETOM OTRYVA POTOKA NA OSNOVE SISTEMY URAVNENIIA EILERA]**

A. P. SHASHKIN (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1985, p. 34-40. In Russian. refs

The problem of supersonic flow of a gas past wings is analyzed with allowance for possible flow separation using complete Euler equations. A numerical implementation of such a flow is presented for delta wings with subsonic edges. The results obtained are verified experimentally. V.L.

**A86-22057#**

**TRANSONIC BLADE TO BLADE CALCULATIONS IN AN AXIAL, RADIAL OR MIXED FLOW CASCADE EQUIPPED WITH SPLITTER BLADES**

F. BERTHEAU (DRET, Paris, France), Y. RIBAUD (ONERA, Chatillon-sous-Bagneux and Palaiseau, France), and V. MILLOUR (ONERA, Chatillon-sous-Bagneux, France) ASME, International Gas Turbine Conferences and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. DRET-supported research. refs
(ASME PAPER 85-GT-86; ONERA, TP NO. 1985-23)

A general computer code for pseudo-unsteady Euler equations integration in turbomachinery cascades has been developed. A quasi-three-dimensional flow hypothesis is assumed and only blade to blade calculation is considered here. Cascades may be axial, radial or mixed flow type. First the computerized quasi-orthogonal network is shown. This network takes into account splitters and is designed to reduce the computation time. Then, the numerical method is described and the major difficulties of this problem, which are boundary conditions, leading edge and trailing edge treatments, are presented. Finally, examples of calculations on turbines and compressors are given with emphasis on graphic representation. Author

**A86-22115#**

**PRODUCTION AND DEVELOPMENT OF SECONDARY FLOWS AND LOSSES WITHIN A THREE DIMENSIONAL TURBINE STATOR CASCADE**

A. YAMAMOTO and R. YANAGI (National Aerospace Laboratory, Chofu, Japan) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 9 p. Research supported by the Ministry of International Trade and Industry. refs
(ASME PAPER 85-GT-217)

Using five-hole pitot tubes, detailed flow measurements were made before, within and after a low-speed three-dimensional turbine stator blade row to obtain quantitative information on the aerodynamic loss mechanism. Qualitative flow visualization tests and endwall static pressure measurements were also made. An analysis of the tests revealed that many vortical flows promote loss generation. Within a large part of the cascade, a major loss process could be explained simply as the migration of boundary layer low energy fluids from surrounding walls (endwalls and blade surfaces) to the blade suction surface near the trailing edge. On the other hand, complexity exists after the cascade and in the vortical flows near the trailing edge. The strong trailing shedding vortices affect upstream flow fields within the cascade. Detailed flow surveys within the cascade under the effects of blade tip leakage flows are also included. Author

**A86-22117#**

**AN ELEVEN PARAMETER AXIAL TURBINE AIRFOIL GEOMETRY MODEL**

L. J. PRITCHARD (Williams International, Walled Lake, MI) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 12 p. refs
(ASME PAPER 85-GT-219)

The mathematical derivation, and FORTRAN code, of a comprehensive but easy to use geometry model for axial flow turbine nozzles and rotors is presented. To uniquely define an airfoil on a cylinder the aerodynamicist need only specify the number of blades, and at each radius of interest: the axial and tangential chord, throat, uncovered turning, leading and trailing edge radii, inlet and exit blade angles, and inlet wedge angle. Default values exist for six of these geometric variables, which proves useful when starting a design. Both the suction and the pressure surfaces are described entirely by analytical functions. Sample airfoils are included that demonstrate the effect of each parameter upon blade shape. Author

**A86-22303#**

**CALCULATION OF EXTERNAL AND INTERNAL TRANSONIC FLOW FIELD OF A THREE-DIMENSIONAL SHIELDED S-SHAPED INLET**

H. SHEN, S. LUO, M. JI, Z. XING, X. ZHU et al. Northwestern Polytechnical University, Journal, vol. 3, Oct. 1985, p. 447-458. In Chinese, with abstract in English. refs

Internal and external three-dimensional transonic flow fields of shield s-shaped inlets are calculated, including the forebody, at different angles of attack and yaw angles. An improved analytical continuation method is developed to treat the boundary condition at the solid surface. When the geometry of objects is complex, the whole computation region is divided into three parts and different physical coordinate systems are applied to each part. Data for the interfaces of neighboring parts are transferred using interpolation formulas, and good convergence and calculational stability are achieved. Sample computations of two s-shaped inlets are performed using the present method, and the results are compared with those obtained by the perturbation method and with experimental results. The comparison indicates that the present method is promising. C.D.

**A86-22311#**

**A VORTEX LATTICE METHOD FOR JET WING PERFORMANCE WITH NONLINEAR WAKE AND TIP FLOW**

Z. CHEN (Beijing Institute of Aerodynamics, People's Republic of China) and J. M. WU (Tennessee, University, Tullahoma) Acta Aeronautica et Astronautica Sinica, vol. 6, Aug. 1985, p. 329-334. In Chinese, with abstract in English. refs

A three-dimensional nonlinear method for determining the aerodynamic performance of a jet flap wing has been developed. The method utilizes a system of bound and free vortices with vortex lattices to represent the wing, jet wake, and tip vortices. This method satisfies both kinematic and dynamic conditions, and takes vortex interaction into consideration. The solutions obtained include chordwise and spanwise load distributions, from which sectional and total aerodynamic qwantities are derived. The jet-wake sheet and the tip vortex shape are determined simultaneously, taking nonlinear effects into account. The solutions agree with other analytical results and available data for a jet wing with large aspect ratio. The method is applicable to cases with large jet blowing angles as well. C.D.

**A86-22319#**

**CALCULATION OF SUPERSONIC FLOWS AROUND A THREE-DIMENSIONAL WING AND A WAISTED BODY WITH CHARACTERISTIC METHOD IN STREAM SURFACE COORDINATES**

B. WANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Aug. 1985, p. 393-396. In Chinese, with abstract in English. refs

**A86-22692#**

**SIMULATION OF DIFFUSER DUCT FLOWFIELDS USING A THREE-DIMENSIONAL EULER/NAVIER-STOKES ALGORITHM**

J. VADYAK (Lockheed-Georgia Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 15 p. Research sponsored by the Lockheed Independent Research and Development Program. refs
(AIAA PAPER 86-0310)

An analysis is presented for calculating steady (or unsteady) three-dimensional aircraft diffuser duct (or thrust nozzle) flowfields. This algorithm can compute the flowfield in axisymmetric or arbitrary asymmetric diffuser duct configurations at subsonic, transonic, or supersonic speeds. The algorithm can solve either the Euler momentum equations for inviscid flow, the thin-shear-layer Navier-Stokes equations for viscous flow, or the full Navier-Stokes equations for viscous flow. The flowfield is determined on a body-fitted numerically-generated computational grid. A fully-implicit alternating-direction-implicit algorithm is employed for solution of the finite-difference equations. Numerical results and correlations with experiment are presented to illustrate application of the analysis. Author

**A86-22693*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**VELOCITY AND TEMPERATURE DECAY CHARACTERISTICS OF INVERTED-PROFILE JETS**

U. VON GLAHN, J. GOODYKOONTZ, and C. WASSERBAUER (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 31 p. Previously announced in STAR as N86-14223. refs
(AIAA PAPER 86-0312)

In order to design efficient, lightweight flap systems for future engine under-the-wing STOL aircraft, the velocity and temperature decay rate of the jet plume must be increased relative to that for single-stream nozzles in order to provide local flap loads and structural temperatures within acceptable limits. The jet plume decay rate of dual flow engines can be increased by resorting to inverted-profile velocity and temperature nozzle concepts. The peak axial decay characteristics of model-scale, two-stream inverted-profile nozzle flows are empirically correlated. Also discussed are the radial and spreading characteristics of inverted-profile nozzle flows. Author

**A86-22701#**

**NUMERICAL ISSUES IN COMPUTING INVISCID SUPERSONIC FLOW OVER CONICAL DELTA WINGS**

S. R. CHAKRAVARTHY and D. K. OTA (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 20 p. refs
(AIAA PAPER 86-0440)

For a thin elliptic cone with half angles 20 degrees and 1.5 degrees, recent numerical results obtained with various methods based on central difference approximations show a distinct difference between solutions obtained on 'fine' and 'coarse' grids. The study reported in this paper began by using methods based on state-of-the-art high-resolution upwind-biased Total Variation Diminishing (TVD) formulations to study the same problem. These techniques resulted in consistent solutions on 'fine', 'coarse', and 'very coarse' grids. A systematic study of the differences between methods based on central and upwind discretizations was then initiated to see if they contributed to the distinct types of solutions obtained with them. After an extensive study, a surprising conclusion emerged: the anomalous behavior of the solutions obtained using central difference approximations need not be due to any fundamental difference between these and upwind schemes, but can be purely a result of using spatially varying time steps. In fact, it is shown in this paper, that such solutions can be obtained with upwind-biased approximations also by using spatially varying time steps. Author

**A86-22702#**

**INFLUENCE OF WING TIP CONFIGURATION ON LATERAL BLOWING EFFICIENCY**

D. TAVELLA, C. S. LEE, and N. J. WOOD (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 5 p. refs
(AIAA PAPER 86-0475)

An experimental investigation of the effect of slot position and orientation on the aerodynamic characteristics of the lateral wing tip blowing concept was conducted. It was found that displacing the slot closer to the upper surface of the wing enhances the lift augmentation. The same happens when the slot is slanted downward. The first effect is primarily viscous, while the second appears to have also an inviscid character. Both effects manifest themselves as distributed increments of lift along the wing span, above the lift augmentation that would be produced by a symmetrically located slot. It is concluded that the offset slot affects the wing aerodynamics through changes in the jet extension into the free stream, rather than through suction forces due to differential entrainment by the two sides of the jet. The effect of jet slant is in qualitative agreement with theoretical predictions. Author

**A86-22704*#** Informatics General Corp., Palo Alto, Calif.

**NUMERICAL SIMULATION OF TRANSONIC SEPARATED FLOWS OVER LOW-ASPECT RATIO WINGS**

U. KAYNAK (Informatics General Corp., Palo Alto, CA), T. L. HOLST, R. L. SORENSON (NASA, Ames Research Center, Moffett Field, CA), and B. J. CANTWELL (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 15 p. refs
(Contract NCA2-OR-745-309)
(AIAA PAPER 86-0508)

Transonic flow fields about a low-aspect-ratio advanced technology wing have been computed using a viscous/inviscid zonal approach. The flow field near the wing where viscous effects are important was solved using the 'Reynolds-Averaged Navier-Stokes Equations' in 'thin-layer' form. The Euler equations were used to determine the flow field in regions away from the wing where viscous effects are insignificant. A zonal grid using an H-H topology was generated around the wing by first solving a set of Poisson's equations for the global grid. This grid was then subdivided into separate zones of viscous or inviscid flow as suggested by the flow physics. A series of flow cases were computed and compared with corresponding sets of experimental data. All cases showed good agreement with experiment in terms of the pressure field. Also, a good correlation between computed separated surface flow and experimental oil flow was obtained. Author

**N86-16191#** Aeronautical Research Labs., Melbourne (Australia).

**A FORTRAN PROGRAM FOR THE DETERMINATION OF UNSTEADY AIRFORCES ON GENERAL COMBINATIONS OF INTERFERING LIFTING SURFACES OSCILLATING IN SUBSONIC FLOW**

W. WALDMAN 1985 92 p refs
(ARL-STRUCT-R-412; AR-003-987) Avail: NTIS HC A05/MF A01

The aeroelastic stability of an aircraft is an important consideration in the overall process of determining its airworthiness. When external bodies or stores are added to the wing of an aircraft, the dynamic characteristics of the aircraft will be changed.

Due to the inertial, elastic and aerodynamic coupling between the wing and its stores the flutter speed of the aircraft may be adversely affected. The aerodynamic coupling may be particularly important if the stores have aerodynamic surfaces, such as fins, that can generate large oscillatory aerodynamic forces. There are a number of computer programs which predict unsteady aerodynamic forces acting on oscillating lifting surfaces. These programs, which are based on the doublet lattice method of Albano and Rodden were optimized for simple interfering wing-tail-fin and control surface cases. They are not applicable to general combinations of interfering lifting surfaces. Thus a requirement exists for a computer program that can calculate unsteady aerodynamic forces for general configurations of interfering lifting surfaces, including a capability for dealing with store aerodynamics. Since the doublet lattice method is readily applicable to interfering and nonplanar lifting surfaces, it is used as the basis of a program capable of dealing with general configurations. The doublet lattice method is versatile and there are essentially no restrictions on the configurations that can be handled as long as an appropriate idealization can be developed. G.L.C.

**N86-16193*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AERODYNAMIC CHARACTERISTICS OF A HIGH-WING TRANSPORT CONFIGURATION WITH A OVER-THE-WING NACELLE-PYLON ARRANGEMENT

W. P. HENDERSON and W. K. ABEYOUNIS Dec. 1985 93 p refs
(NASA-TP-2497; L-15959; NAS 1.60:2497) Avail: NTIS HC A05/MF A01 CSCL 01A

An investigation has been conducted in the Langley 16-Foot Transonic Tunnel to determine the effects on the aerodynamic characteristics of a high-wing transport configuration of installing an over-the-wing nacelle-pylon arrangement. The tests are conducted at Mach numbers from 0.70 to 0.82 and at angles of attack from -2 deg to 4 deg. The configurational variables under study include symmetrical and contoured nacelles and pylons, pylon size, and wing leading-edge extensions. The symmetrical nacelles and pylons reduce the lift coefficient, increase the drag coefficient, and cause a nose-up pitching-moment coefficient. The contoured nacelles significantly reduce the interference drag, though it is still excessive. Increasing the pylon size reduces the drag, whereas adding wing leading-edge extension does not affect the aerodynamic characteristics significantly. Author

**N86-16194*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### VALIDATION OF VISCOUS AND INVISCID COMPUTATIONAL METHODS FOR TURBOMACHINERY COMPONENTS

L. A. POVINELLI 1986 19 p refs Proposed for presentation at the 31st International Gas Turbine Conference, Dusseldorf, West Germany; sponsored by ASME
(NASA-TM-87193; E-2765; NAS 1.15:87193) Avail: NTIS HC A02/MF A01 CSCL 01A

An assessment of several three-dimensional computer codes used at the NASA Lewis Research Center is presented. Four flow situations are examined, for which both experimental data and computational results are available. The four flows form a basis for the evaluation of the computational procedures. It is concluded that transonic rotor flow at peak efficiency conditions may be calculated with a reasonable degree of accuracy, whereas, off-design conditions are not accurately determined. Duct flows and turbine cascade flows may also be computed with reasonable accuracy whereas radial inflow turbine flow remains a challenging problem. Author

**N86-16195*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### A NUMERICAL SIMULATION OF THE INVISCID FLOW THROUGH A COUNTER-ROTATING PROPELLER

M. L. CELESTINA (Sverdrup Technology, Inc., Cleveland, Ohio), R. A. MULAC (Sverdrup Technology, Inc., Cleveland, Ohio), and J. H. ADAMCZYK 1986 23 p refs Proposed for presentation at the 31st International Gas Turbine Conference, Dusseldorf, West Germany, 8-12 Jun. 1986; sponsored by ASME
(NASA-TM-87200; E-2855; NAS 1.15:87200) Avail: NTIS HC A02/MF A01 CSCL 01A

The results of a numerical simulation of the time-averaged inviscid flow field through the blade rows of a multiblade row turboprop configuration are presented. The governing equations are outlined along with a discussion of the solution procedure and coding strategy. Numerical results obtained from a simulation of the flow field through a modern high-speed turboprop will be shown. Author

**N86-16196*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### FLOW FIELD SURVEY NEAR THE ROTATIONAL PLANE OF AN ADVANCED DESIGN PROPELLER ON A JETSTAR AIRPLANE

K. R. WALSH 1985 29 p refs
(NASA-TM-86037; H-1226; NAS 1.15:86037) Avail: NTIS HC A03/MF A01 CSCL 01A

An investigation was conducted to obtain upper fuselage surface static pressures and boundary layer velocity profiles below the centerline of an advanced design propeller. This investigation documents the upper fuselage velocity flow field in support of the in-flight acoustic tests conducted on a JetStar airplane. Initial results of the boundary layer survey show evidence of an unusual flow disturbance, which is attributed to the two windshield wiper assemblies on the aircraft. The assemblies were removed, eliminating the disturbances from the flow field. This report presents boundary layer velocity profiles at altitudes of 6096 and 9144 m (20,000 and 30,000 ft) and Mach numbers from 0.6 to 0.8, and it investigated the effects of windshield wiper assemblies on these profiles. Because of the unconventional velocity profiles that were obtained with the assemblies mounted, classical boundary layer parameters, such as momentum and displacement thicknesses, are not presented. The effects of flight test variables (Mach number and angles of attack and sideslip) and an advanced design propeller on boundary layer profiles - with the wiper assemblies mounted and removed - are presented. Author

**N86-16197*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### MACH NUMBER AND FLOW-FIELD CALIBRATION AT THE ADVANCED DESIGN PROPELLER LOCATION ON THE JETSTAR AIRPLANE

L. D. WEBB Dec. 1985 21 p refs
(NASA-TM-84923; H-1222; NAS 1.15:84923) Avail: NTIS HC A02/MF A01 CSCL 01A

Advanced design propellers on a JetStar aircraft were tested at NASA Ames Research Center's Dryden Flight Research Facility. A calibration of the flow field at the test location to obtain local Mach number and flow direction was performed. A pitot-static probe and flow direction vane installation was installed and tested at Mach 0.3 to 0.8 and altitudes from 3000 m (10,000 ft) to 9100 m (30,000 ft). Local Mach number and flow direction relationships were obtained and related to their noseboom counterparts. Effects of varying angles of sideslip to + or - 3 deg. were investigated. Author

**N86-16199*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PRESSURE DISTRIBUTIONS FROM HIGH REYNOLDS NUMBER TESTS OF A BOEING BAC 1 AIRFOIL IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL**

W. G. JOHNSON, JR. and A. S. HILL Dec. 1985 271 p refs
(NASA-TM-87600; L-16010; NAS 1.15:87600) Avail: NTIS HC A12/MF A01 CSCL 01A

A wind-tunnel investigation designed to test a Boeing advanced-technology airfoil from low to flight-equivalent Reynolds numbers has been completed in the Langley 0.3-Meter Transonic Cryogenic Tunnel. This investigation represents the first in a series of NASA/U.S. industry two-dimensional airfoil studies to be completed in the Advanced Technology Airfoil Test program. Test temperature was varied from ambient to about 100 K at pressures ranging from about 1.2 to 6.0 atm. Mach number was varied from about 0.40 to 0.80. These variables provided a Reynolds number (based on airfoil chord) range from 4.4 X 10 to the 6th power to 50.0 X 10 to the 6th power. All the test objectives were met. The pressure data are presented without analysis in plotted and tabulated formats for use in conjunction with the aerodynamic coefficient data published as NASA TM-81922. At the time of the test, these pressure data were considered proprietary and have only recently been made available by Boeing for general release. Data are included which demonstrate the effects of fixed transition. Also included are remarks on the model design, the model structural integrity, and the overall test experience. Author

**N86-16200#** Sandia National Labs., Albuquerque, N. Mex.

**SIX DEGREE OF FREEDOM SIMULATION OF FLUID PAYLOAD PROJECTILES USING NUMERICALLY COMPUTED FLUID MOMENTS**

H. R. VAUGHN, W. P. WOLF, and W. L. OBERKAMPF Jul. 1985 102 p
(Contract DE-AC04-76DP-00789)
(DE85-017183; SAND-85-1166) Avail: NTIS HC A06/MF A01

A flight trajectory simulation method has been developed for calculating a six degree of freedom motion of fluid filled projectiles. Numerically calculated internal fluid moments and experimentally known aerodynamic forces and moments are coupled to the projectile motion. Comparisons of predicted results with flight test data of an M483 155mm artillery projectile with a highly viscous payload confirm the accuracy of the simulation. This simulation clearly shows that the flight instability is due to the growth of the nutation component of angular motion caused by the viscous effects of the fluid payload. This simulation procedure, when used in conjunction with the previously developed method for calculating internal fluid moments, allows the designer to examine the effects of various liquid payloads and container geometries on the dynamic behavior of flight vehicles. DOE

**N86-16202#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**IMPLICIT FINITE-DIFFERENCE METHODS FOR THE CALCULATION OF UNSTEADY TRANSONIC POTENTIAL FLOW AROUND TWO-DIMENSIONAL AIRFOILS: A DISCUSSION**

J. VANDERVOOREN and H. SCHIPPERS 23 Sep. 1985 33 p refs Submitted for publication
(NLR-MP-83063-U; B8566372) Avail: NTIS HC A03/MF A01

Mathematical modeling of unsteady transonic flow is discussed. Starting from the Euler equations, potential theory is derived and applied to the flow about a 2D airfoil. Motions considered include rigid body motions and deformations of the airfoil. The full-potential equation is formulated on curvilinear coordinates maintaining strong conservation form. Boundary conditions on the airfoil, wake conditions and radiation type far-field conditions are assessed. A numerical method based on time-linearization of the differential equation up to second order accuracy is presented. The resulting equation can be integrated numerically by an implicit locally one-dimensional split method. Approximation of spatial derivatives by fully conservative finite difference schemes employing mass-flux splitting for the capture of shocks is treated. Results for the steady flow about an airfoil illustrate that an Engquist-Osher type scheme at the sonic line is a prerequisite to rigorously suppress nonphysical expansion shocks. Author (ESA)

**N86-16203#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**AN EXPERIMENTAL INVESTIGATION OF THE ENTRAINMENT INTO A LEADING-EDGE VORTEX**

N. G. VERHAAGEN and L. VANDERSNOEK 1984 60 p refs
(VTH-LR-332) Avail: NTIS HC A04/MF A01

The theoretical distribution of the velocity inside the rotational core of a leading-edge is derived using Stewartson and Hall's (1963) outer solution for the rotational core. From it the entrainment into and the circulation around the rotational core is derived. The theoretical results are compared with results from measurements on the leading-edge vortex of a sharp-edged unit aspect ratio delta wing. The measurements were performed for an angle of attack of 20 deg at 45 m/sec, corresponding to a Reynolds number of 2.5 million, based on centerline chord. A relation for the entrainment factor found in the literature is shown to be incorrect. Author (ESA)

**N86-16204#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**APPLICATION OF TIME-LINEARIZED METHODS OF OSCILLATING WINGS IN TRANSONIC FLOW AND FLUTTER**

M. H. L. HOUNJET and J. J. MEIJER 15 Aug. 1984 21 p refs Presented at AGARD Specialists Meeting on Unsteady Aerodynamics and Aeroelastic Applications, Toulouse, France, 2-7 Sep. 1984 Sponsored by Royal Netherlands Air Force, The Hague
(NLR-MP-84077-U; B8569322) Avail: NTIS HC A02/MF A01

Unsteady aerodynamic loads in the transonic domain were obtained with time-linearized methods in which a so-called field panel method which accounts for a proper radiation of signals towards infinity is embedded. The methods are used to predict the unsteady loads and first harmonic pressure distributions on an airfoil and a transport type wing. Results are correlated with data of unsteady experiments and of other calculation methods. Transonic flutter applications to a fighter-type configuration are described. Author (ESA)

**N86-16205#** Technische Hogeschool, Delft (Netherlands). Dept. of Mathematics and Informatics.

**CALCULATIONS OF TRANSONIC FLOWS AROUND SINGLE AND MULTIELEMENT AIRFOILS ON A SMALL COMPUTER**

Z. NOWAK 1984 32 p refs Sponsored by Netherlands Organization for the Advancement of Pure Research
(REPT-84-48) Avail: NTIS HC A03/MF A01

A method based on finite volume discretization of the full potential equation with artificial compressibility for calculating transonic flows around single and multielement airfoils is presented. The velocity potential is calculated on a succession of grids by the line-Newton method. For multielement airfoils, the channels between the component parts are treated with the line-Newton relaxation or underrelaxation procedure. The method is quite efficient for relatively coarse grids (size 21 x 64 or 17 x 64). For finer grids convergence could be improved by multigrid methods. A method for generating nearly orthogonal grids in double-connected regions using simple semianalytic formulas is given. The grids are strictly orthogonal at the inner boundary. Author (ESA)

**N86-16206#** European Space Agency, Paris (France).
**INVESTIGATION OF THE AERODYNAMIC FORCES ON BLUFF BODIES AT HIGH REYNOLDS NUMBERS Final Report**
G. SCHEWE Jun. 1985 37 p refs Transl. into ENGLISH of "Untersuch. der aerodynamischen Kraeft, die auf stumpfe Profile bei grossen Reynolds-Zahlen Wirken" Report DFVLR-Mitt-84-19 Goettingen, West Germany, 1984 Original report in GERMAN previously announced as ESA-94556
(ESA-TT-914; DFVLR-MITT-84-19) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne DM 13

Steady and unsteady forces acting on a circular cylinder, a square-section cylinder and an H-profile (Tacoma Bridge) were investigated in a pressurized wind tunnel (very high Reynolds numbers). The forces were measured by a piezo-multicomponent balance, which features a large dynamic range, low interference and a high natural frequency. The Reynolds number (Re) range between 20,000 and 7 million is investigated with the same circular cylinder and balance by merely varying flow velocity and air density. In the critical Reynolds number range, bistable asymmetric flow states which can be controlled by a very small perturbation are observed. The investigation of the square section reveals no strong Reynolds number effects in the range Re between 100,000 and 4 million. The Tacoma profile is shown to be aeroelastically unstable in torsion mode. Author (ESA)

**N86-17271#** National Aerospace Lab., Tokyo (Japan).
**NUMERICAL SIMULATION OF THE LEADING-EDGE SEPARATION VORTEX OVER DELTA WING**
K. FUJII *In its* Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 27-34 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A thin-layer Navier-Stokes code capable of predicting steady state viscous flows is applied to complicated three-dimensional flow fields. The code is written in a generalized coordinate system, and a recently developed grid generation procedure is used for the flow-field discretization. Application is made to the vortical flow over a delta wing at high angle of attack, and the computed results are compared with experimental results. The results indicate that the present method can capture the physical phenomenon well. It is served that a leading-edge separation vortex is formed over the wing, as is a secondary separation vortex near the leading edge. The flow field behind the trailing edge is also well described. Author

**N86-17273#** National Aerospace Lab., Tokyo (Japan).
**NUMERICAL SIMULATION OF UNSTEADY FLOW AROUND AN AIRFOIL BY FINITE DIFFERENCE SOLUTION OF NAVIER-STOKES EQUATIONS**
S. OGAWA and T. ISHIGURO *In its* Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 43-52 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A numerical procedure for solving the flow field generated by a moving body is presented based on a finite difference solution of Navier-Stokes equations. A conservation-law form of the equations in a general time-varying coordinate system is derived from the Cartesian expression by applying the concept of Lie derivatives. Specifically, a moving coordinate expression of the streamfunction-vorticity formulation is derived, and is used for the analysis of the dynamic-stall phenomenon of an oscillating airfoil in incompressible flow. A computation example is given for an NACA 0012 airfoil oscillating in pitch at an amplitude of 10 deg about a mean angle of attack of 15 deg with a reduced frequency of 0.4 pi and a Reynolds number of 20,000 based on the chord length and the uniform advance speed of the airfoil. Author

**N86-17278#** Metropolitan Coll. of Technology, Tokyo (Japan).
**TRANSONIC INTERNAL FLOW ABOUT AN AIRFOIL OSCILLATING IN PITCH: COMPARISONS BETWEEN COMPUTATION AND EXPERIMENT**
T. SHIRATORI and Y. TANIDA (Tokyo Univ., Japan) *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 85-90 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

As a preliminary investigation into the relationship between the transonic flutter characteristics and the shock behavior of a transonic cascade, a numerical analysis using a finite-difference method was carried out for a cascade oscillating in pitch about its midchord anti-phase with each other and a zero stagger angle, based on an assumption of inviscid flow. The computational method was examined by comparisons of computational results with experimental results of the shock wave periodic movements due to oscillation of the cascade, unsteady surface pressure and aerodynamic instability. Although quantitative differences in both results exists, which were caused by the presence of shock-boundary interaction in real phenomenon, the present computation was useful in the investigation of qualitative aspects of the shock wave behavior, aerodynamic instability and the relations between them. In such computation, it is necessary to make the computational mesh size small in comparison to the displacement of the shock wave. Author

**N86-17285#** National Aerospace Lab., Tokyo (Japan).
**INVESTIGATIONS ON EFFICIENT NUMERICAL METHOD FOR SUBSONIC LIFTING SURFACES**
S. ANDO *In its* Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 149-162 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

This is an intermediate summary report on the numerical investigation of subsonic unsteady lifting surface. This work describes simple planar cases. Most of the results thus obtained would be fundamentally useful even for more complicated problems, such as non-planar wings or wings with finite thickness. The results are divided into the following three main parts: (1) introduction of error-index parameters E, and development of an adaptive numerical method for lifting surfaces. (2) Improvement of numerical calculation of the subsonic kernel function. (3) Development of new, accurate, fast-converging numerical methods for lifting surfaces. For two-dimensional airfoils a DLM-C method has been developed. For finite span wings a finite aerodynamic element method (DSM-CLS) and two pressure mode methods (NAM, NAS) have been developed. Author

**N86-17289#** Kyoto Inst. of Tech. (Japan).
**NUMERICAL ANALYSIS FOR STEADY TRANSONIC FLOWS PAST AN AIRFOIL USING AF SCHEME**
N. SATOFUKA and H. NISHIDA *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 193-200 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

An approximate factorization scheme has been developed for analyzing transonic flows past an airfoil. In this scheme, upwind differencing is used for introducing artificial viscosity in the supersonic region and central differencing is used in the subsonic region. The resulting simple two- and three-banded matrices are solved by the relaxation procedure. This scheme is fully implicit, and in principle can be combined with the solution adaptive method. In both sub- and super-critical cases, the computed surface pressure distributions for an NACA0012 airfoil are in good agreement with those obtained by other methods. Author

**N86-17290#** Kyoto Inst. of Tech. (Japan).
**NUMERICAL SOLUTION OF VISCOUS COMPRESSIBLE FLOWS PAST AN AIRFOIL USING UNCONDITIONALLY STABLE EXPLICIT METHOD**
N. SATOFUKA and Y. NISHIDA *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 201-212 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

An unconditionally stable explicit method has been applied to compute compressible laminar flows past an NACA0012 airfoil. The method is based on a combination of central differencing for spatial derivatives with a rational Runge-Kutta time integration scheme. Both transonic (M = 0.8) and supersonic (M = 2.0) flow cases have been calculated for various Reynolds numbers. Physically plausible results are obtained for each case within practically feasible CPU time. Author

**N86-17291#** Nihon Univ., Tokyo (Japan). College of Science and Technology.
**NUMERICAL ANALYSIS ABOUT FLOW OVER AN AEROFOIL WITH A LARGE ANGLE OF ATTACK**
K. ONO *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 213-220 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

The results of numerical computations on the dynamic stall process of a two dimensional NACA0012 airfoil oscillating in pitch between 0 deg and 20 deg incidence angles are summarized. The uniform flow Mach number is set to 0.3. The Beam-Warming finite difference algorithm is applied to solve the time-averaged compressible Navier-Stokes, the laminar compressible Navier-Stokes and the Euler equations. The grid system is constructed based on a body-fitted curvilinear coordinate system for efficient unsteady flow computations. The computational results are compared with the experimental data. The process of the formation of the leading edge separation bubble, its convection along the airfoil surface and its shedding into the wake is fairly well simulated. But the abrupt drop of the lift coefficient is not detected in the computations. Judging from the pressure coefficient distribution, the Euler equations results give the best agreement with the experiment. It suggests that the effective local Reynolds number in the turbulent calculation is smaller than that in the actual flow field. A more precise estimation of the turbulence viscosity, the artificial one and the truncation error is necessary. Author

**N86-17292#** Nagoya Univ. (Japan). Dept. of Aeronautical Engineering.
**NUMERICAL ANALYSIS OF TRANSONIC FLOW AROUND TWO-DIMENSIONAL AIRFOIL BY SOLVING NAVIER-STOKES EQUATIONS**
Y. Y. WANG and T. FUJIWARA *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 221-228 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

An effective finite-difference scheme for solving full compressible Navier-Stokes equations was initiated by Beam and Warming. The purpose of this paper is to develop that technique and apply it to the calculation of a typical subsonic or transonic, inviscid or viscous steady flow. First, the strong conservation-law form of the Navier-Stokes equations is written in Cartesian coordinates, and then transformed into a general grid system. Following the Beam-Warming difference scheme, the parameter combination delta=1/2 and theta=1 is generally adopted. After introducing spatial factorization, second-order dissipative terms are added to the left-hand side, while fourth-order terms are added to the right-hand side; the fourth-order smoothing terms are changed to second-order terms at points adjacent to the boundaries. The numerical computations were carried out only for a typical NACA 0012 airfoil. The calculations start from uniform free-stream variables throughout the flow field. The boundary conditions in the far field are free-stream. The following four cases are calculated: (1) M sub infinity = 0.63 and alpha=0, causing an entirely subsonic flow, (2) M sub infinity = 0.63 and alpha=2 degrees, the highest velocity of upper surface being close to sonic; (3) M sub infinity = 0.75 and alpha=0, when supersonic regions appear but there are no shock waves, and (4) M sub infinity = 0.75 and alpha=2 degrees, generating a shock wave over the upper flow field. Author

**N86-17293#** National Aerospace Lab., Tokyo (Japan).
**ANALYSIS OF HIGH REYNOLDS NUMBER TRANSONIC FLOW AROUND AN AIRFOIL**
N. KAWAI and N. HIROSE *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 229-234 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

High Reynolds number transonic flow around an airfoil is numerically analyzed. The implicit approximate factorization scheme is used for the Navier-Stokes equations with an algebraic eddy viscosity model of the turbulent boundary layer. The boundary conditions on the airfoil and along the wake cut are implicitly handled. Computed results of short bubble and shock-induced separation are demonstrated. Inviscid transonic flow around and airfoil is also numerically analyzed. The diagonal form of the implicit approximate factorization scheme is used for computational efficiency. Some of the results are compared with those of potential flow calculations. Author

**N86-17294#** National Aerospace Lab., Tokyo (Japan).
**VALIDATION AND COMPARISON WITH EXPERIMENT OF A HIGH REYNOLDS NUMBER TRANSONIC FLOW AIRFOIL ANALYSIS CODE NSFOIL**
N. HIROSE, N. KAWAI, K. OGUCHI, and T. KODERA *In its* Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 235-244 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Results of the two-dimensional Navier-Stokes code, NSFOIL, are compared with wnd tunnel data. Pressure distributions for various airfoil geometries are evaluated with special emphasis given to the NACA 0012 airfoil. Reynolds number values from 1.0 to 2.0 to the 7th power and Mach numbers from 0.7 to 2.0 are considered. M.G.

**N86-17295#** Mitsubishi Heavy-Industries Ltd., Tokyo (Japan).
**THE COMPARISON OF THE TRANSONIC AIRFOIL CALCULATION BY NSFOIL WITH THE WIND TUNNEL TEST DATA AT HIGH REYNOLDS NUMBER**
J. MIYAKAWA and N. HIROSE (National Aerospace Lab., Tokyo, Japan) *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 245-254 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Over the past decade, the progress in computational aerodynamics has been so tremendous that it can be said that designers in aircraft industries have obtained a tool for aerodynamics analysis other than wind tunnel test, which had been their only tool since the invention of the aircraft. The new technology has become an even more efficient design tool with the development of computer aided design systems for interactive processing. All of the practical aerodynamics codes, however, are inviscid or boundary-layer-corrected programs which are accurate enough for analyzing attached flows but not for separated flows. Severe design trade off for recent high performance aircraft has necessitated accurate numerical analysis of viscous separated flows. The high Reynolds number transonic airfoil analysis code NSFOIL, is expected to be a good candidate for this difficult task. This paper presents the NSFOIL computation of the transonic flow past a supercritical airfoil, along with a comparison with the experiment to show the effectiveness of the new code. Author

**N86-17300#** Nihon Univ., Tokyo (Japan).
**THE ANALYSIS OF PRACTICAL TRANSONIC SWEPT WINGS WITH AND WITHOUT BOUNDARY LAYER EFFECTS**
K. KOMATSU, E. IIDA, R. KAWAMURA, N. HIROSE (National Aerospace Lab., Tokyo, Japan), and K. MATSUNO (National Aerospace Lab., Tokyo, Japan) *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 305-312 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A comparison of the result of numerical analysis with experimental data is made for the ONERA M-6 and the practical transonic wing model 720211. The Jameson-Caughey's transonic wing programs FLO22 and FLO27 are used. The wing aerodynamic characteristics with viscous effect are evaluated by taking into account the boundary layer friction drag. This drag is calculated by using a three-dimensional compressible boundary layer program for wings, BLAY. Finally, a viscous-inviscid interaction procedure for FLO27-BLAY is proposed, and a preliminary result is presented. Author

**N86-17305** Engineering Sciences Data Unit, London (England).
**ESTIMATION OF DRAG DUE TO INOPERATIVE TURBO-JET AND TURBO-FAN ENGINES USING DATA ITEM NOS. 81009 AND 84004**
Jul. 1984 12 p Submitted for publication
(ESDU-84005; ISBN-0-85679-467-8; ISSN-0141-4054) Avail: ESDU

ESDU 84005 illustrates how data on windmilling drag and airflow and on spillage drag are used to predict the drag due to the inoperative engine. The data are respectively taken from ESDU 81009 and ESDU 84004, but other sources could be used. Where ESDU data are used the method is particular suited to cases where the particular engine, or intake, data are not available. Author

**N86-17307** Royal Aircraft Establishment, Farnborough (England).
**STUDIES OF THE FLOW FIELD NEAR A NACA 4412 AEROFOIL AT NEARLY MAXIMUM LIFT**
R. C. HASTINGS and B. R. WILLIAMS 20 Dec. 1984 35 p refs
(RAE-TM-AERO-2026; BR96009) Avail: NTIS HC A03/MF A01

Measurements at Mach number 0.18 and chord-based Reynolds number 4.2 million on a constant-chord model having a NACA 4412 airfoil are compared with the results of flow field calculations. The measurements include static pressure distributions on the wing surface and on the wind tunnel walls above and below the mid-span section of the wing. The development of the upper surface boundary layer through separation (at 20% chord ahead of the trailing-edge) and on into the wake, was studied using laser anemometry. The flow field calculations are of the semi-inverse kind in which an inverse momentum-integral treatment of the shear flow, used to avoid difficulties at separation, is coupled to a direct solution of the inviscid flow problem. Results reveal the importance of shear flow in altering the disturbance introduced into the free stream by the airfoil. Measure and predictions agree well. Author (ESA)

**N86-17308#** National Aerospace Lab., Tokyo (Japan).
**ESTIMATION OF DIVERGENCE AND FLUTTER BOUNDARIES ON SUPERSONIC PLATE WING MODELS FROM SUBCRITICAL RANDOM RESPONSES DUE TO AIR TURBULENCE**
Y. ANDO, Y. MATSUZAKI, H. EJIRI, and T. KIKUCHI 1985 17 p refs In JAPANESE; ENGLISH summary
(NAL-TR-856; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The National Aerospace Laboratory (NAL) method was applied to the response data which were obtained from subcritical flutter and divergence tests conducted in the NAL supersonic wind tunnel. Backward- and forward-swept wing models were used for the flutter and divergence tests, respectively. The stationary sampled time responses were modeled by both the autoregressive moving average (ARMA) and autoregressive (AR) processes. It has been shown that both flutter annd divergence boundaries in a supersonic flow range can well be estimated as those in the transonic flow region. Author

**N86-17310#** Sandia National Labs., Albuquerque, N. Mex.
**INTRODUCTION TO DEPLOYABLE RECOVERY SYSTEMS**
J. MEYER Aug. 1985 31 p
(Contract DE-AC04-76DP-00789)
(DE86-000048; SAND-85-1180) Avail: NTIS HC A03/MF A01

This report provides an introduction to deployable recovery systems for persons with little or no background in parachutes but who are knowledgeable in aerodynamics. A historical review of parachute development is given along with a description of the basic components of most deployable recovery systems. Descriptions are given of the function of each component and of problems that occur if a component fails to perform adequately. Models are presented for deployable recovery systems. Possible directions for future work are suggested in the summary. DOE

**N86-17314#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**LOW SPEED AERODYNAMIC CHARACTERISTICS OF A TWO-DIMENSIONAL SAIL WING WITH ADJUSTABLE SLACK OF THE SAIL**
R. G. DENBOER 1984 38 p refs
(VTH-LR-307) Avail: NTIS HC A03/MF A01

Low speed aerodynamic characteristics of a very simple dacron airfoil were investigated in a low speed, low turbulence wind tunnel. The influence of the slack of the sail on the lift coefficient cl, drag coefficient cd, and cl/cd, was studied. Measurements were performed at chord Reynolds numbers 200,000, 300,000, and 500,000 at values of the angle of attack and slack of the sail where relatively high values of the ratio cl/cd occurred. Results show that the value (cl/cd)max of the airfoil exceeds the value (cl/cd)max of a similar configuration in which a rigid circular plate of 10% camber is used instead of a sail. Author (ESA)

**N86-17316#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
**TRANSONIC WIND TUNNEL TESTS OF A SWEPT SUPERCRITICAL WING-BODY MODEL, PT 8 Final Report**
L. TORNGREN Feb. 1985 110 p refs
(Contract FMV-F-K-82223-75-007-07-001; FMV-F-K-82223-76-001-21-001; FMV-F-K-82223-80-001-21-001)
(FFA-TN-1982-24) Avail: NTIS HC A06/MF A01

Wind tunnel tests were carried out in the Mach number range 0.5 to 0.99 on a swept wing-body model. The investigation comprises six-component balance measurements, wing pressure measurements, and flow visualization. Wings with and without strakes, but with the same quarter-chord sweep of 35 deg were tested on a cylindrical and an area ruled body. Pressure measurements were only done on the wing with strakes. For the model with this wing, the effects of underwing and wingtip mounted stores were also studied. Author (ESA)

**N86-17320#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
**APPLICATION OF A CONSTRAINED INVERSE METHOD IN THE AERODYNAMIC DESIGN OF A LOW SPEED WING-SLAT CONFIGURATION**
J. A. VANEGMOND, B. VANDENBERG, and T. E. LABRUJERE 30 Sep. 1983 36 p refs
(Contract NIVR-1901)
(NLR-TR-83123-U; B8569027) Avail: NTIS HC A03/MF A01

A system for computational design of multielement airfoils was developed. It solves the inverse aerodynamic problem in an approximate way. A priori specified aerodynamic requirements and geometric requirements are minimized in a least squares way, introducing weight factors to emphasize locally aerodynamic or geometric requirements. The system was applied to a wing with slat, exhibiting unfavorable drag characteristics. The design focused on the wing nose geometry at the slat intersection. To improve the drag characteristics a target pressure distribution was defined with a reduced suction level on the wing nose. The computations indicated that this target could be achieved with satisfactory approxiation (fulfilling at the same time a set of geometry requirements). This is confirmed by wind tunnel measurements. The tests also show a substantial drag reduction. Author (ESA)

**N86-17321#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**A SYSTEM FOR COMPUTER AIDED ANALYSIS AND DESIGN OF MULTIELEMENT AIRFOILS: MAD**

T. E. LABRUJERE 9 Oct. 1983 33 p refs
(Contract NIVR-1819; NIVR-1944)
(NLR-TR-83136-U; B8569026) Avail: NTIS HC A03/MF A01

A program system for interactive analysis and design of multielement airfoils in incompressible viscous flow was developed. It applies three computational methods, one for the analysis of viscous flow, one for the analysis of inviscid flow around multielement airfoils, and one for the design of multielement airfoils in inviscid flow. The latter two methods are described. Features of the design method are illustrated by numerical results.
Author (ESA)

# 03

# AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-19301**

**SAFE ASSOCIATION, ANNUAL SYMPOSIUM, 22ND, LAS VEGAS, NV, DECEMBER 9-13, 1984, PROCEEDINGS**

Van Nuys, CA, SAFE Association, 1985, 398 p. For individual items see A86-19302 to A86-19353.

The present conference on aircraft life support and escape systems considers the fire safety of commercial aircraft cabins, acceleration exposure limits for escape system development, the development of a zero-prebreathe spacesuit, an impermeable chemical defense protective ensemble, crew escape capsule technology, helicopter escape methods, an altitude and acceleration protection system for high performance aircraft, molecular sieve oxygen supply systems, vectored thrust digital control of ejection seats, and ballistically deployed parachutes for small aircraft. Also discussed are control law and logic development for an ejection seat catapult, real time recovery of vehicle data, escape system simulation methods, an underwater high pressure emergency breathing system, simulator sickness, decompression sickness, and the use of gliding parachutes for ejection seats.
O.C.

**A86-19319**

**BALLISTICALLY DEPLOYED PARACHUTE SYSTEMS FOR SINGLE AND TWO PLACE AIRCRAFT**

P. J. WOODRUFF (Pioneer Parachute Co., Inc., Manchester, CT) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 128-131.

Ballistically deployed parachute systems have been developed for single- and two-place aircraft. A parachute system which utilizes a 29-foot nominal diameter parachute is used to recover the 'FlightStar', an aircraft which meets ultralight requirements. A parachute system which utilizes a 36-foot nominal diameter parachute is used to recover single-place aircraft which do not meet ultralight requirements, as well as the 'DualStar', a two-place ultralight training aircraft. Author

**A86-19323**

**ACCIDENT INVESTIGATION AS A WAY OF ASSESSING AVIATION LIFE SUPPORT SYSTEM PERFORMANCE**

B. W. TRENHOLM (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 151-156.

Separately and statistically, the Aviation Life Support Systems (ALSS) survival equipment involved in ejections and crashes provides real-life data on its performance. An inspection process for the accident-involved ALSS equipment has been developed to assist in identifying and correcting potential problems. The procedure consists of an in-depth inspection of all recovered components performed in the functional/operational sequence of the parachute assembly: (1) the external pilot chute, (2) the override disconnect, (3) the internal pilot parachute, (4) the main canopy, (5) the suspension lines, (6) the spreading gun assembly, (7) the riser assemblies, (8) the cross-connector straps, (9) the canopy release fittings (female halves), (10) the automatic parachute ripcord release assembly, (11) the container, (12) the MA-2 torso harness, and (13) the parachute assembly configuration. All findings are documented on applicable damage charts, establishing a logical procedure for determining the step or steps in the parachute assembly that malfunctioned. I.S.

**A86-19326**

**USING FLEET REPORTED 3-M DATA IN SUPPORT OF NAVY EMERGENCY ESCAPE PARACHUTE ASSEMBLIES**

M. A. MARTIN (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 164-168.

The Fleet Support Branch of the Aerosystems Department, Naval Weapons Center (NWC), has the task to perform failure trend analyses on the basis of the Maintenance and Material Management (3-M) data for Navy emergency escape parachute assemblies and ther components. Details regarding the involved operations and the data bases are discussed, and the significance of the analyses is evaluated. When used in conjunction with the quality deficiency reporting system, the technical publication deficiency reporting system, and the accident investigation reports, 3-M allows an organized approach to the solution of Fleet parachute problems. G.R.

**A86-19334**

**THE CANADIAN FORCES TWIN OTTER AIRCRAFT OPERATIONS IN THE ARCTIC - A THERMAL ASSESSMENT**

G. R. GAMBLE and T. ROMMET IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 212-215.

The objectives of this paper were to assess the degree of cold stress that Twin Otter aircrew are subjected to during Arctic operations, and to determine what equipment inadequacies or deficiencies were producing the high level of cold stress reported by aircrew working in this environment. Various physiological and environmental monitoring systems were utilized to assess the effects of the environment on crew members. Although comfort levels were low, no signs of even mild hypothermia were observed, however, instances of conductive cooling due to fuel spillage were observed. Improved thermal protection of the face is required, as is fuel and water protection of the hands and feet. A lightweight heater to raise aircraft interior temperatures after lengthy shut-downs would also be an asset. Author

**A86-19335**

**THE ANATOMY OF SEA SKAD (SURVIVAL KIT AIR DROPPABLE) - A CANADIAN FORCES/INDUSTRY DEVELOPMENT PROGRAM**

C. B. LOCKETT IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 216-219.

The present paper is concerned with the development of a survival kit of system which is dropped from an aircraft to persons in distress at sea. In Canada, search and rescue operations are a responsibility of the Defense Department. The SKAD project was started in connection with a requirement for Maritime Command to fulfill its secondary search and rescue (SAR) mandate with the new long range patrol aircraft, the P-3 Orion, which is called Aurora. It is pointed out that frequently these aircraft are the only Canadian Forces resource with the necessary speed, range, and endurance to perform specific tasks in the more remote regions of Canada's area of responsibility. Attention is given to efforts to seek a source of SKAD development from Canadian industry, the selection of a suitable company, the start of the development in late 1981, problems of functional demonstration, and the start of production. Each SKAD consists of two 10 person life rafts and sufficient equipment for up to 20 survivors.
G.R.

**A86-19352**

**A PHILOSOPHICAL BASIS FOR THE USE OF HIGH-PERFORMANCE, GLIDING PARACHUTES IN EJECTION SEAT AIRCRAFT**

M. C. BUTLER, JR. (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 356-361.

A ram-air inflated, gliding parachute wing capable of meeting or exceeding the performance of a round parachute in all categories, from opening shock to landing impact, is described. One of the major advantages of the ram-air parachute (RAP) over the round parachute (RP) is its inherent gliding capabilities, which increase, by a factor of 39, the area that the enemy must search in order to find the ejectee. Other advantages include the extremely fast opening characteristics of RAP, its stability in all flight modes, and its much lower rate of descent than that of an RP of comparable pack volume. A rate of descent of 15 ft/s at 300 lb suspended weight has been demonstrated at an L/D of 2.5. Data available indicate that the RAP is much more reliable than the RP when compared in the same type of applications. The costs and the time required to manufacture an RAP are the same as those of an RP.
I.S.

**A86-19353**

**COMPENSATING-SLIT CANOPY DESIGN - A NEW LOW-SPEED/HIGH-SPEED PARACHUTE**

D. C. HASS (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 362-366.

The Naval Weapons Center's (NWC's) 'compensating-slit' parachute was developed to meet a requirement for a singular parachute canopy design that would possess desirable opening shock and descent characteristics at both low and high operational airspeeds. Through the employment of a properly located tear-out slit around the perimeter of the canopy, which remains closed at low airspeed openings and opens at high airspeed openings, this parachute concept enjoys a dual-personality characteristic which results in desirable performance at both ends of the operational airspeed spectrum. Phase one of a two-phase test program, consisting of Whirltower tests and aircraft drop tests under varied test conditions, has been accomplished. Modified, standard 28-foot-diameter, flat, circular canopies (28FCs) were used in phase one because of their low cost and ease of fabrication. However, the newly-developed compensating-slit canopy is being used in phase two.
Author

**A86-19637*#** National Severe Storms Lab., Norman, Okla.

**LIGHTNING STRIKES TO A NASA AIRPLANE PENETRATING THUNDERSTORMS AT LOW ALTITUDES**

V. MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK), B. D. FISHER (NASA, Langley Research Center, Hampton, VA), and J. C. GERLACH (NASA, Wallops Flight Center, Wallops Island, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs

(AIAA PAPER 86-0021)

The NASA Storm Hazards program was dedicated during the 1984 storm season to a study of lightning strikes on an instrumented F-106B aircraft, during penetrations of thunderstorms at altitudes lower than the 6-8 km center of lightning flash density. These altitudes coincide with the negative charge region of thunderstorms. An analysis of the correlation between the UHF band radar data obtained and TV images of lightning strikes indicates that, with a known aircraft position relative to the radar, the lightning channel motion can be adequately interpreted on the basis of radar echo evolution.
O.C.

**A86-19737#**

**WIND SHEAR CHARACTERIZATION**

H.-P. CHANG, D. W. CAMP (FWG Associates, Inc., Tullahoma, TN), W. FROST (Tennessee, University, Tullahoma), and J. MCCARTHY (National Center for Atmospheric Research, Boulder, CO) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(AIAA PAPER 86-0180)

Computer simulations of a B727 type aircraft flying through the JAWS microburst wind shear data have been developed and the results evaluated. The results are in good agreement with those obtained from the NASA/Ames B727 piloted simulator. The aircraft trajectory deviations from the intended flight path at the ILS CAT II decision height window are calculated for finding critical penetration heights through the center of the microburst. Based on the aircraft's dynamic responses in the simulations, the JAWS microburst wind fields are classified into light, moderate, and severe cases, which represent interesting simulator training scenarios. Finally, the wind shear effects on three generic types of aircraft, a three-engine passenger airliner, a twin-engine STOL, and an executive jet, are investigated. Large jet aircraft experience greater difficulty in flight through microburst wind shear fields than smaller aircraft.
Author

**A86-19813#**

**DETERMINING THE EFFECTS OF WEATHER IN AIRCRAFT ACCIDENT INVESTIGATIONS**

J. C. MCLEAN, JR. (National Transportation Safety Board, Washington, DC) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.

(AIAA PAPER 86-0323)

Weather is often a principal factor in aircraft accidents and the documentation and analysis of the weather elements becomes a major part of the accident investigation. Selected accident investigations are reviewed to describe some of the techniques used to determine what weather elements may be pertinent or critical to an accident, the sources of weather information, and the methods of analyzing the information to satisfy the requirements of the investigation.
Author

**A86-19814#**

**METEOROLOGICAL FACTORS IN SELECTED AIRCRAFT ACCIDENT INVESTIGATIONS**

R. E. CALE (E.R.A. Services, Inc., Cerritos, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 6 p.

(AIAA PAPER 86-0324)

Post-analysis of accident environments provides an opportunity for considerably better meteorological information than is possible with forecast services. This is due to having data after the fact as well as before, and the time to pursue in-depth analysis of available data - specializing the effort to each particular problem. Examples are given from a number of case studies of the use of applied meteorological techniques to determine environmental factors

useful to aeronautical experts in determining probable cause.
Author

**A86-19815#**
**WEATHER-INVOLVED U.S. AIR CARRIER ACCIDENTS 1962-1984 - A COMPENDIUM AND BRIEF SUMMARY**
R. D. RUDICH (Air Transportation Consultants, Ltd., Alexandria, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 8 p. refs
(AIAA PAPER 86-0327)

The documentation of 32 aircraft accidents which occurred over the past quarter century and were related to weather phenomena are summarized. All the accidents were investigated by the NTSB and the findings are cited. A total of 16 types of passenger aircraft were involved in the accidents, which resulted in a total of 789 fatalities and 321 additional serious injuries. Thunderstorms were the most frequent meteorological condition associated with accidents, closely followed by severe wind shear (microburst) events. Failures of cockpit personnel and aircraft-ATC to communicate available weather data are frequently cited as the situations which led to the accidents. M.S.K.

**A86-19860*#** Massachusetts Inst. of Tech., Cambridge.
**REAL-TIME MEASUREMENT OF ICE GROWTH DURING SIMULATED AND NATURAL ICING CONDITIONS USING ULTRASONIC PULSE-ECHO TECHNIQUES**
R. J. HANSMAN, JR. and M. S. KIRBY (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. FAA-supported research.
(Contract NGL-22-009-640)
(AIAA PAPER 86-0410)

Results of tests to measure ice accretion in real-time using ultrasonic pulse-echo techniques are presented. Tests conducted on a 10.2 cm diameter cylinder exposed to simulated icing conditions in the NASA Lewis Icing Research Tunnel and on an 11.4 cm diameter cylinder exposed to natural icing conditions in flight are described. An accuracy of + or - 0.5 mm is achieved for real-time ice thickness measurements. Ice accretion rate is determined by differentiating ice thickness with respect to time. Icing rates measured during simulated and natural icing conditions are compared and related to icing cloud parameters. The ultrasonic signal characteristics are used to detect the presence of surface water on the accreting ice shape and thus to distinguish between dry ice growth and wet growth. The surface roughness of the accreted ice is shown to be related to the width of the echo signal received from the ice surface. Author

**A86-20162#**
**THE LIGHTNING THREAT TO AEROSPACE VEHICLES**
P. L. RUSTAN, JR. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 62-67. Previously cited in issue 07, p. 851, Accession no. A85-19516. refs

**A86-20166#**
**APPLICATION OF KEVLAR TO PARACHUTE SYSTEM DESIGN**
C. W. PETERSON, W. B. PEPPER, D. W. JOHNSON, and I. T. HOLT (Sandia National Laboratories, Albuquerque, NM) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 87-92. Previously cited in issue 11, p. 1498, Accession no. A84-26574. refs
(Contract DE-AC04-76DP-00789)

**A86-20411**
**AIRPORT PREPAREDNESS FOR MASS DISASTER - A PROPOSED SCHEMATIC PLAN**
G. I. BARBASH, S. M. RUSKIN, D. W. MOELLER (Harvard University, Boston, MA), and N. YOELI (Israel Air Force, Aeromedical Center, Ramat Gan) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, Jan. 1986, p. 77-81. refs

The characteristics which make airport accidents different from other nonaircraft accidents are described. Immediate evaculation of the casualties and their transport to medical facilities is the basis of an airport rescue operation. The utilization of the airport crew, close medical aid, and distant medical facilities is examined. The notification of the medical personnel of an emergency and means of providing orientation and guidance for them at the airport are analyzed. Management of the crash site, including development of the medical staff and evacuation and treatment of the casualities, especially burn victims and uninjured passengers, by a command group, is discussed. The advantages of practicing a disaster plan are addressed. I.F.

**N86-16207#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
**AIRCRAFT ACCIDENT REPORT: MIDAIR COLLISION OF WINGS WEST AIRLINES BEECH C-99 (N666U) AND AESTHETEC INC., ROCKWELL COMMANDER (N112SM), NEAR SAN LUIS OBISPO, CALIFORNIA, AUGUST 24, 1984**
24 Aug. 1984 52 p
(NTSB/AAR-85/07) Avail: NTIS HC A04/MF A01

At 1117:38 Pacific daylight time, on August 24, 1984, Wings West Airlines, Flight 628, a Beech C-99 (N6399U), and Aesthetec Inc., Rockwell Commander 112TC, N112SM, collided in midair near San Luis Obispo, California. The weather at the time of the collision was clear. Flight 628 had just departed San Luis Obispo County Airport en route to San Francisco International Airport, California, and was climbing on a westbound heading. The Rockwell Commander had departed Paso Robles, California, on a training flight and was descending toward the San Luis Obispo County Airport on an eastbound track. The airplanes collided head-on at an altitude of about 3,400 feet. The wreckage of both airplanes fell into an open field 8 nmi west northwest of the San Luis Obispo County Airport. All 17 persons, including the 2 pilots and 13 passengers onboard flight 628 and the 2 pilots onboard the Rockwell, were killed. The National Transportation Safety Board determines that the probable cause of this accident was the failure of the pilots of both aircraft to follow the recommended communications and traffic advisory practices for uncontrolled airports contained in the Airman's Information Manual to alert each other to their presence and to enhance the controller's ability to provide timely traffic advisories. Author

**N86-16208*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**SOME COMPARISONS OF US AND USSR AIRCRAFT DESIGN DEVELOPMENTS**
M. L. SPEARMAN Dec. 1985 36 p refs Previously announced in IAA as A86-10930
(NASA-TM-87611; NAS 1.15:87611) Avail: NTIS HC A03/MF A01 CSCL 01C

A review is given of the design and development of some US and USSR aircraft. The emphasis is on the historical development of large aircraft-civil and military transports and bombers. Design trends are somewhat similar for the two countries and indications are that some fundamental characteristics are dictated more by ideological differences rather than technological differences. A brief description is given in a more or less chronological order of the major bomber aircraft, major civil and military transport aircraft, and the development of the air transport systems. Author

**N86-17324#** Committee on Science and Technology (U. S. House).
**CONTROLLED IMPACT DEMONSTRATION (CID)**
Washington GPO 1985 82 p Hearing before the Subcommittee on Transportation, Aviation and Materials of the Committee on Science and Technology, 99th Congr., 1st Sess., no. 13, 2 Apr. 1985
(GPO-46-870) Avail: Subcommittee on Transportation, Aviation and Materials

A congressional hearing was conducted and expert testimony presented on the controlled impact demonstration. The experimental worth of crashing an airplane for the purpose of gaining hard data on crashworthiness was discussed. G.L.C.

**N86-17325#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**HARDWARE/SOFTWARE FAILURE MODE EFFECT ANALYSIS (FMEA) APPLIED TO AIRPLANE SAFETY**

J. B. J. VANBAAL 31 Jul. 1984 9 p refs Presented at 1985 Annual Reliability and Maintainability, Philadelphia, Pa., 22-24 Jan. 1985

(NLR-MP-84073-U; B8568107) Avail: NTIS HC A02/MF A01

A systematic, analytical methodology for aircraft system safety assessment is explained. A try-out on a software controlled digital avionics system is summarized. Analysis of software components is emphasized. It is concluded that the same methodology can be applied to software and hardware. Conditions that have to be met to perform a successful hardware/software safety assessment are described. Author (ESA)

**N86-17328#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.

**THE DEICED SUPER PUMA**

J. P. SILVANI 1985 10 p refs Presented at 11th European Rotorcraft Forum, London, England, 10-13 Sep. 1985

(SNIAS-852-210-104) Avail: NTIS HC A02/MF A01

The efficiency of helicopter ice protection systems was studied in flight test with natural icing conditions, in icing wind tunnel tests and analytically. The icing wind tunnel tests were intended to develop and validate air intake and horizontal stabilizer icing protections. Proper operation of all protections is verified in natural icing flight down to -20 C in continuous and intermittent icing conditions. Author (ESA)

**N86-17329#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.

**SEARCH AND RESCUE (SAR) SYSTEM DEVELOPED AS PART OF THE CONTRACT SIGNED WITH THE IRISH AIR CORPS FOR THE SUPPLY OF 365 F DAUPHIN AIRCRAFT**

S. RIOCHE 1985 15 p Presented at 11th European Rotorcraft Forum, London, England, 10-13 Sep. 1985

(SNIAS-852-210-105) Avail: NTIS HC A02/MF A01

A helicopter-borne search and rescue system, including a fully automatic guiding function and an electronic flight instrument system was developed. The first includes automatic search patterns and descent to hovering near the designated target, implemented by a navigation computer and a flight director computer. The second includes a display of horizontal situation parameters, attitude and radar. The versatility of the system makes it compatible with a wide variety of other requirements, both civil and military. Author (ESA)

**N86-17330#** Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. Systemes Balistiques et Spatiaux.

**SYSTEMS SAFETY: PHANTOM OR REALITY [SECURITE DES SYSTEMES: FANTOME OU REALITE]**

P. LAVEDRINE 1985 10 p In FRENCH Presented at 3rd Seminaire Europeen sur la Securite des Systemes, Cannes, France, 19-21 Sep. 1984

(SNIAS-852-422-103) Avail: NTIS HC A02/MF A01

The juridical aspects of manufacturer's liability in case of safety failure, particularly in the case of aircraft accidents, are discussed. The moral aspects and responsibilities of designers are examined. Author (ESA)

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-20520**

**AIRCRAFT TERMINAL AREA GUIDANCE BASED ON THE DISCRETE TRACKING PROBLEM OF OPTIMAL CONTROL THEORY**

J. E. MARINE and J. E. BENNETT (Clemson University, SC) IN: SOUTHEASTCON '84; Proceedings of the Conference, Louisville, KY, April 8-11, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 399-402. refs

An aircraft terminal area landing approach system based upon the Discrete Tracking Problem of Optimal Control Theory is presented. The control vector is made up of the aircraft's thrust and flight path. An example of the landing approach system is presented. Author

**A86-21327**

**LOCAL AREA COMMAND/CONTROL NETWORKS: THE DESIGN OF AN ON-BOARD NETWORK - ANTINEA [RESEAUX LOCAUX DE COMMANDE-CONTROLE: CONCEPTION D'UN RESEAU EMBARQUE - ANTINEA]**

J.-C. VALADIER Toulouse, Institut National Polytechnique, Doctorat Thesis, 1985, 142 p. In French. refs

A design is proposed for a local area network (LAN) for use on aircraft. The LAN is intended for avionics system which feature distributed interconnected computers. In aircraft, operations must be in real-time with a reaction time of less than 0.5 msec to avoid compromising flight safety. The ANTINEA project was initiated in 1982 to develop a second generation LAN which would acommodate distributed command/control points. The goal was to increase the number of possible data exchanges, lower the access time, and ensure reliability in the system. The ANTINEA system includes 40 Mbps operational rate using optical fiber links. Each signal travels unidirectionally through a repeater unit, which may be redundant. Simple computations can be carried out on a decentralized basis, while overall computational reliability is directly dependent on the extent of redundancy built into this token ring system. Reliability is further enhanced if the system architecture includes a backup token ring. Finally, techniques are discussed for assigning priorities to control the data traffic and minimize the system access time. M.S.K.

**A86-21606**

**EVOLUTION OF THE AIR TRAFFIC CONTROL BEACON SYSTEM**

C. F. PHILIPS (Westinghouse Defense and Electronics Systems Center, Baltimore, MD) The Controller (ISSN 0010-8073), vol. 24, Dec. 1985, p. 18-20, 22-24.

The operation of the air traffic control (ATC) beacon system in modes A and C is described. The interference problem in the controller's display resulting from the increased number of aircraft with transponders is investigated; the synchronization of replies with the interrogation rate of the ground interrogator and staggering of regional interrogation rates eliminates this interference. The operation of the sidelobe suppression system designed to reduce sidelobe interference is examined. The development of a 5 foot high open array to reduce interference is discussed. The design of mode S, which reduces the number of ground interrogations, for the operation of the beacon system is described. The monopulse processing, selective interrogation, and digital data link of mode S are analyzed. I.F.

**A86-21607**

**RADARS IN AIR TRAFFIC CONTROL - A STATUS REPORT**

P. A. JORGENSEN (Selenia S.p.A., Rome, Italy) The Controller (ISSN 0010-8073), vol. 24, Dec. 1985, p. 25-27.

Advances in radar system designs are discussed. The advantages and function of a multiradar tracking (MRT) system, which utilizes all available radar data to develop a one system track for each aircraft, are examined. The operation of the radar head processor (RHP), which combines data from all radar systems and performs local tracking, is described. MRT and RHP are to reduce the error in range and azimuth. The testing of the MRT and RHP is analyzed. I.F.

**A86-21608**

**PLESSEY DISPLAYS IN AIR TRAFFIC CONTROL**

A. FIELD The Controller (ISSN 0010-8073), vol. 24, Dec. 1985, p. 30-32.

Technological advances which have increased the application of radars to air traffic control are: (1) improved performance of primary radar sensors, (2) the development of a secondary surveillance, (3) digital data processing, and (4) display changes. The design and functions of Watchman, a new generation of autonomous intelligent displays, are examined. The display, which has improved clarity, and the console, which contains a display and data processing system, are integrated. The capabilities the display adds to the radar presentations are listed. The ability of the controller to access all available data as desired is studied. An example of a controller's data display request is provided. I.F.

**N86-16209** Civil Aviation Authority, London (England).

**EVALUATION OF 23 INCH RADAR VIEWING UNIT FOR HEATHROW APPROACH CONTROL ROOM**

Jul. 1985 24 p refs

(CAA-PAPER-85011; REPT-516) Avail: Issuing Activity

The possibility of replacing pairs of 16 in approach radar viewing units (RVU) by single 23 in units was assessed in a simulation with 20 air traffic controllers. The subjective and numerical evidence indicates that a single 23 inch RVU is an acceptable replacement. The lack of suitable range settings made it difficult for controllers to comment about the suitability of the RVU for the initial planning task. However, the indications are that the monitoring and sequencing tasks could be carried out satisfactorily. In the event of an RVU failure, a controller could maintain a radar service for a maximum of 5 min by sharing a neighboring RVU. Author (ESA)

**N86-17331** Bundesanstalt fuer Flugsicherung, Frankfurt am Main (West Germany).

**ACTIVITIES IN AIR TRAFFIC CONTROL Annual Report, 1984**

Jun. 1985 50 p In GERMAN

Avail: Issuing Activity

Measures to enhance air traffic safety and regularity, performance of air traffic services, operational problems, and air traffic incidents are discussed. Navigation and radiotelephony techniques, information transmission techniques, radar techniques, and air traffic control technical services are described. Activities of the office for passenger information, flight measurements, construction plans, education and advanced training, and cooperation in the framework of international aviation organization are summarized. Author (ESA)

**N86-17333#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abt. Traegheitsortung und Navigation.

**CONSTRUCTION OF A MEASURING METHOD USING FIBER OPTICS AND AN LTN-90 LASER GYRO STRAPDOWN SYSTEM FOR BO-105 HELICOPTERS**

H. J. HOTOP and H. P. ZENZ May 1985 48 p refs In GERMAN; ENGLISH summary

(DFVLR-MITT-85-10; ISSN-0176-7739) Avail: NTIS HC A03/MF A01; DFVLR, Cologne DM 19

A Modular Universal Data Acquisition System 2 (MUDAS 2) equipped with an LTN-90 laser gyro strapdown navigation system and with a fiber optic data bus for transmission of ARINC-429 signals was developed for onboard testing of navigation systems. It was tested on a BO-105 helicopter during flights for applicability on helicopters and flexibility in data acquisition and recording. The system was studied on long distance flights and on strong maneuver flights. Signals of the LTN-90 system were compared with the data of the Precision Automated Tracking System laser radar. Application of fiber optics for data transmission of bit serial signals (200 Hz NRZ Code) is proved. The LTN-90 navigation system designed for surface aircraft can be applied without loss of accuracy. Author (ESA)

**N86-17334#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**A SOPHISTICATED TRACKING ALGORITHM FOR AIR TRAFFIC CONTROL (ATC) SURVEILLANCE RADAR DATA**

H. A. P. BLOM 9 Jan. 1984 10 p refs Presented at International Conference on Radar, Paris, France, 21-24 May 1984

(NLR-MP-84004-U; B8566260) Avail: NTIS HC A02/MF A01

An algorithm based on martingale tools for application to sudden aircraft maneuvers in radar tracking was developed. It is a Markov jump-diffusion model. It provides very accurate state estimates during unchanged flight modes, very fast reaction and convergence after changes, and good estimates of its own accuracy. Comparison with an alpha-beta tracker, a Kalman based tracker, and a state-of-the-art tracker proves the superior performance of the algorithm. Author (ESA)

**N86-17335#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**COMPARISON OF A JUMP-DIFFUSION TRACKER WITH A KALMAN TRACKER: AN EVALUATION WITH EMPHASIS ON AIR TRAFFIC CONTROL**

H. A. P. BLOM 30 Mar. 1983 39 p refs

(NLR-TR-83063-U; B8569022) Avail: NTIS HC A03/MF A01

Radar tracking algorithms are compared. A probabilistic approach to the tracking problem is a Markov jump-diffusion model for the aircraft dynamics, its control, and the radar measurements. From nonlinear filtering theory, a closed form description of the evolution of the conditional distribution of this Markov process can be obtained. This jump-diffusion filter, however, is infinite dimensional and approximations are necessary for algorithmic implementation. The indirect approach of approximating the jump-diffusion by a diffusion leads to a Kalman-like tracker. The approach of approximating the jump-diffusion filter directly leads to a bank of interacting Kalman-like trackers. Comparison for air traffic control shows that the jump-diffusion tracker performs considerably better than the Kalman tracker. Author (ESA)

# 05

# AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-19303**

**A SINGLE POINT RELEASE SYSTEM FOR THE ADVANCED CONCEPT EJECTION SEAT (ACES) II - SURVIVAL KIT AND PARACHUTE RISERS**

T. N. WHITEHURST, JR. (Boeing Services International, Inc., Houston, TX) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 41-45. refs
(Contract F33657-81-C-0368)

Attention is given to the electroexplosive system developed to provide the Advanced Concept Ejection Seat II with a safe and reliable Single Point Release System (SPRS) employing automatic, sea water-activated parachute riser releases. Design features and performance factors of the SPRS are presented. Tests of the prototype SPRS have been conducted with two F-16 seats, occupied by dummies and filmed at 200 frames/sec. O.C.

**A86-19305**

**YAW STABILIZATION OF AN OPEN EJECTION SEAT, FACT OR FANTASY?**

W. R. PECK (Stencel Aero Engineering Corp., Asheville, NC) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 51-54.

A discussion is presented of efforts to date toward the development of yaw stabilization systems for high performance aircraft ejection seats, having as a goal the reduction of crew injuries due to lateral accelerations. Such systems entail compatibility with existing aircraft cockpits, and stabilization elements that are passive and aerodynamic in nature. Attention is given to several prepossessing designs, as well as to Mach 0.3 and 0.75 aerodynamic data obtained through wind tunnel testing of one of these devices. O.C.

**A86-19306**

**THE FUTURE OF ADVANCED CREW ESCAPE CAPSULE TECHNOLOGY**

D. E. MCCAULEY (McDonnell Aircraft Co., St. Louis, MO) and M. I. DARRAH (McDonnell Douglas Corp., St. Louis, MO) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 59-62.

This presentation reviews technology and biodynamics pertinent to crew escape for future high performance fighters. It discusses various capsules and their materials, supporting subsystems, limits, and adaptations necessary to permit survival when conditions exceed human tolerance. Hazards associated with escape are also presented, including temperature extremes, hypoxia, low pressure, and high accelerations. Discussions will emphasize high speed, high altitude atmospheric fighters, and transatmospheric vehicles. The escape capsule systems of the future will require continual sensing of critical parameters, offering the prognosis of an artificially intelligent escape system, predicated on life support of the crew. Author

**A86-19307**

**DEVELOPMENT OF MECHANICAL COMPONENTS FOR ADVANCED AIRCREW SEATING SYSTEMS**

R. L. FARRIS (Pacific Scientific Co., Kin-Tech Div., Anaheim, CA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 63-66.

A discussion is conducted concerning the development status, design features and obtainable performance of mechanical components used in the crew seats of advanced aircraft as safety/escape devices. Attention is given to crew harness inertia reels, harness systems, lap belt cinchers, inflatable head and body restraints, infinite rotary positioners, vapor springs, and mechanical linear load limiters. Both rotary and fixed wing aircraft crew seating equipment are considered. O.C.

**A86-19308**

**THE CONTINUING REQUIREMENT FOR HELICOPTER ESCAPE**

W. L. TRAYNOR (Stencel Aero Engineering Corp., Asheville, NC) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 67-70. refs

An evaluation of the development history of helicopter crew survivability measures and devices in the U.S. leads to the observation that efforts have concentrated in the area of vehicle crashworthiness to the exclusion of in-flight escape. It is noted that the high helicopter damage probability experienced in Vietnam conflict battles as a result of heavy Soviet-built machine gun fire has direct implications for future encounters of such weapons by U.S. combat helicopters. O.C.

**A86-19311**

**F-111 ESCAPE SYSTEMS - TODAY'S MODULE TECHNOLOGY**

G. W. LARSON (General Dynamics Corp., Fort Worth, TX) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 77-80.

The crew module, in its use in the F-111, has proven to be an excellent escape system. The first ejection occurred in October 1967. Statistically, since that time the percentage of safe ejections has been equal to or better than that of open seat systems. Because of the large number of explosive components in the module, the major effort for improvements has been toward extending the service life of these units. New developments in fabrication techniques that permit the design of hermetically sealed subassemblies now provide life-of-airplane capability for explosive devices. Author

**A86-19314**

**ALTITUDE AND ACCELERATION PROTECTION SYSTEM FOR HIGH PERFORMANCE AIRCRAFT**

A. GUPTA and M. B. MCGRADY (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 95-98.

An advanced, integrated breathing and anti-G system capable of providing aircrew protection for altitude exposures up to 60,000 feet and sustained accelerations up to 9 G(Z) is presented. The system utilizes an On-Board Oxygen Generating System controlled by a fast response fluidic oxygen partial pressure sensor, and a fast acting electronic anti-G valve. Significant features include (1) automatic selection and control of breathing gas supply, (2) simultaneous controlled pressurization of G-suit, jerkin, mask and mask-tensioning bladders, (3) low breathing resistance, (4) simple control and indication, and (5) high system integrity during probable failure conditions or ejection. Author

**A86-19316**

**AIRCREW ESCAPE SYSTEM MODELS USED IN WIND TUNNEL TESTS**

F. J. SACKLEH (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 103-108.

The AEDC 16-ft and 4-ft transonic wind tunnels (16T and 4T) have supported the development of ejection seats for Air Force aircraft. This paper describes the wind tunnel models and model supporting hardware used on representative tests and also describes planned improvements in separation test capabilities. In the 16-ft transonic wind tunnel, subscale models of developmental ejection seats and capsules have been tested. Instrumentation include internally mounted six-component balances, anthropomorphic dummies with surface strain gages, and pressure transducers. Jettison plumes are simulated with high-pressure air, and effectiveness of various stabilizing devices are evaluated. Model attitudes are varied within wide ranges of pitch angle and yaw angle. In the 4T transonic wind tunnel, a separation test using two separate stings for canopy and aircraft was recently accomplished. This two-sting capability is also planned for the larger 16-ft wind tunnel. Author

**A86-19317**

### DEVELOPMENT OF AN ELECTRO-PNEUMATIC ANTI-G VALVE FOR HIGH PERFORMANCE FIGHTER AIRCRAFT

R. E. VAN PATTEN, T. J. JENNINGS, W. ALBERY, J. W. FRAZIER (USAF, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH), and C. GOODYEAR (Systems Research Laboratories, Inc., Dayton, OH) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 112-116. USAF-supported research. refs

A new concept for an anti-G suit valve was designed and built at the Air Force Aerospace Medical Research Laboratory. The valve is designed specifically to protect aircrew from the unique physiological hazard of high onset rate, high sustained acceleration. The design is a hybridization of a conventional inertially operated valve, and uses an electronically controlled solenoid to drive the anti-G suit pressure to the maximum when the level of acceleration exceeds both +2 G(z) and an onset rate of 2 G/sec. After a 1.5-sec period, the valve reverts to inertial operation unless the trigger criteria are fulfilled again. Relaxed tolerance of 15 human subjects was determined under high rate of onset centrifuge testing of the new valve (with and without ready pressure) versus the standard valve and a high flow ready pressure valve. The new concept provides a 1 G improvement over the standard valve, and a 0.5 G improvement over the high flow ready pressure valve. On the basis of published data taken under similar conditions, the new valve appears to provide a 0.5 G improvement over all electronic servo valves. Pilot acceptance of this rapid acting concept has been favorable. Author

**A86-19318**

### VECTORED THRUST DIGITAL CONTROL OF EJECTION SEATS

J. V. CARROLL (Scientific Systems, Inc., Cambridge, MA) and M. K. KLUKIS (Martin Marietta Engineering Computer Center, Orlando, FL) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 117-121. USAF-supported research. refs

A closed loop control law design for open ejection seats is presented and discussed. The combination of worsening survival statistics during crew escape in recent years and improving control component technology has made such a study timely and practical. The control technique is based on nonlinear acceleration control, which exploits very well the unique and highly nonlinear characteristics of the pilot/seat system. This paper reviews the design of the controller, including the related actuator configuration and microprocessor architecture issues. A breadboard hybrid simulation, utilizing a wire-wrapped electronic digital controller and a unique vectored thrust actuation concept, has been developed for real time analysis of the concept and is also discussed in this paper. This real time ejection seat controller breadboard analysis capability represents a major step in the evolution of the 'smart' seat, from concept and digital simulation to fabrication, sled testing and production. This design represents a reasonable approach for the control of the seat in its harsh, highly constrained environment, over diverse escape conditions. Author

**A86-19320**

### CONTROL LAW AND LOGIC DEVELOPMENT FOR CONTROLLABLE EJECTION SEAT CATAPULT

A. K. TRIKHA (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 132-137.
(Contract F33615-83-C-3045)

An adaptive ejection seat catapult has been developed which can adjust its thrust to variations in seat/crewperson weight, propellant temperature, and airplane g values. As a result, the rail tipoff velocity can be maximized without exceeding the crewperson's dynamic response index. Simulation results are presented to show that the objective has been met for flight conditions with variations in crewmember/seat weight between 272 to 444 lb, operating temperatures ranging from -65 to +160 F, and the aircraft acceleration of +10 g (compression) to -3 g (tension). The catapult diagram and the control law and logic diagram are included. I.S.

**A86-19331**

### A MICROPROCESOR SEQUENCER FOR THE ADVANCED NAVY EJECTION SEAT

P. AYOUB (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 195-199.

In the case of current Navy Escape Systems, only a limited number of operational modes is available. As an example, a present operational system uses a total of four timing modes to cover the entire ejection cycle. The present paper is concerned with an alternative to the fixed mode selection. A great improvement in system performance is achieved by utilizing currently available microprocessor technology to analyze airspeed and altitude inputs and select from a wide range of programmed operational modes. It is pointed out that this improvement is realized without a sacrifice to system reliability. G.R.

**A86-19339**

### CONTROLLABLE EJECTION SEAT CATAPULT PROGRAM

S. J. BAUMGARTNER (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 237-245.

The Controllable Ejection Seat Catapult (CESC) Program is being sponsored by Air Force Wright Aeronautical Laboratories, Flight Dynamics Laboratory, Crew Escape Branch (AFWAL/FIER). The contract was awarded to an American aerospace company on September 16, 1983. An ejection seat catapult has the function to propel the ejection seat out of an aircraft cockpit during emergency ejection conditions. According to the operational performance objective for the catapult, the velocity reached at the end of the catapult stroke is to be maximized without reaching acceleration levels which are harmful to the crewperson. Under certain conditions, the fixed performance capability of the present day catapult becomes unacceptable. The considered program was initiated with the objective to develop a catapult which is free of the drawbacks of the currently used models, taking into account a catapult concept capable of providing a controllable thrust level for a conventional upright ejection seat. G.R.

**A86-19573**

### VERY LARGE STATIONARY AERIAL PLATFORMS

R. S. LEONARD (BDM Corp., Albuquerque, NM) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 446-457. Research supported by the BDM Corp. refs

The development of rigid, semirigid, and nonrigid airships, to operate at altitudes above 40,000 ft for environmental monitoring, ship traffic control, surveillance, and as high altitude observatories is examined. A comparison of airships with aircraft is presented;

the advantages of modern airships are discussed. The materials used for the structure of the airship, which consists of rings, griders, wire bracing, outer skin fabrics, and gas cells, are described. The powering of the airship with electricity from microwave energy is studied. Potential construction sequences which will make the development of the airship economically feasible are analyzed. I.F.

**A86-19632*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DIVERGENCE STUDY OF A HIGH-ASPECT RATIO, FORWARD-SWEPT WING**

S. R. COLE (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0009)

A study has been conducted in the NASA-Langley Transonic Dynamics wind tunnel to determine the divergence characteristics of a high aspect ratio forward swept wing of rectangular planform, for sweep angles of zero, -15, -30, -45, and -60 deg. In addition to a rectangular wingtip, a tip whose geometry lay parallel with the freestream flow was tested at a sweep angle of -45 deg. The primary objective was to obtain data that could be used to verify the divergence prediction capabilities of an aeroelastic analysis code employing kernel function aerodynamics. The analytical predictions of convergence were found to be conservative for all forward sweep angles, and the effect of the two tip shapes on divergence dynamic pressure were accurately predicted. O.C.

**A86-19674#**

**DESIGN OF A TWIN-ENGINE SHORT-HAUL COMMUTER AIRCRAFT FOR THE 1990S**

E. D. COOPER and D. W. MCKENNA (California Polytechnic State University, San Luis Obispo) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs
(AIAA PAPER 86-0077)

Taking fuel economy as the primary design criteria for a low direct operating cost (DOC) commuter airliner for the 1990s, a configuration incorporating a 'joined wing' planform and pusher propfans was developed which is projected to yield substantial increases in propulsion efficiency and decreases in weight and drag. The DOC of this design, which is noted to depend on no high risk, novel technologies, was found to be significantly lower than a comparably scaled cantilever wing aircraft. Operating costs were found to be comparable. O.C.

**A86-19851*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LABORATORY STUDY OF THE EFFECTS OF SIDEWALL TREATMENT, SOURCE DIRECTIVITY AND TEMPERATURE ON THE INTERIOR NOISE OF A LIGHT AIRCRAFT FUSELAGE**

K. E. HEITMAN and J. S. MIXSON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0390)

This paper describes a laboratory study of add-on {coustic treatments for a twin-engine, propeller-driven aircraft fuselage. The sound source was a pneumatic-driver, with attached horn to simulate propeller noise distribution, powered by a white noise signal. Treatments included a double-wall, production-line treatment and various fiberglass and lead-vinyl treatments. Insertion losses, space-averaged across six interior microphone positions, were used to evaluate the treatments. In addition, the effects of sound source angle and ambient temperature on interior sound pressure level are presented. The sound source angle is shown to have a significant effect on one-third octave band localized sound pressure level. While changes in ambient temperature are shown to have little effect on one-third octave band localized sound pressure level, the change in narrowband localized sound pressure level may be dramatic. Author

**A86-19868*#** Integrated Systems, Inc., Palo Alto, Calif.

**FLIGHT TEST MANEUVER MODELING AND CONTROL**

P. K. A. MENON, R. A. WALKER (Integrated Systems, Inc., Palo Alto, CA), and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs
(Contract NAS2-11877)
(AIAA PAPER 86-0426)

The use of automated flight test schemes decrease the aircraft flight testing time and pilot work load while enhancing the data quality. Two major elements involved in developing such an automated technique are maneuver modeling to generate command histories from the maneuver specifications and the synthesis of control systems to track these command histories. This paper describes the maneuver modeling for eight flight test trajectories. The control system synthesis with Kosut's suboptimal minimum error excitation linear quadratic regulator approach is presented. The closed-loop simulation results are given. Author

**A86-19894*#** Lockheed-Georgia Co., Marietta.

**DEVELOPMENT OF PNEUMATIC THRUST-DEFLECTING POWERED-LIFT SYSTEMS**

R. J. ENGLAR (Lockheed-Georgia Co., Marietta), J. H. NICHOLS, JR., M. J. HARRIS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD), J. C. EPPEL, and M. D. SHOVLIN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs
(AIAA PAPER 86-0476)

Improvements introduced into the Circulation Control Wing/Upper Surface Blowing (CCW/USB) STOL concept (Harris et al., 1982) are described along with results of the full-scale static ground tests and model-scale wind tunnel investigations. Tests performed on the full-scale pneumatic thrust-deflecting system installed on the NASA QSRA aircraft have demonstrated that, relative to the original baseline configuration, a doubling of incremental thrust deflection due to blowing resulted from improvements that increased the blowing span and momentum, as well as from variations in blowing slot height and geometry of the trailing edge. A CCW/Over the Wing model has been built and tested, which was shown to be equivalent to the CCW/USB system in terms of pneumatic thrust deflection and lift generation, while resolving the problem of cruise thrust loss due to exhaust scrubbing on the wing upper surface. I.S.

**A86-19904#**

**THE BASICS OF ON-BOARD SIMULATION AND EMBEDDED TRAINING**

B. J. BRADY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), R. P. MEYER, R. E. LAMBERT, and C. A. SCOLATTI (McDonnell Aircraft Co., St. Louis, MO) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs
(Contract F33615-78-C-3601)
(AIAA PAPER 86-0493)

Embedded training systems (ETS) which use on-board helmet-mounted displays (HMD) to turn fighter aircraft into real-time in-flight simulators are described. A threat situation is presented on the HMD by the ETS computer program and is treated as real by all avionics, thereby joining the features of ground-based simulation and tactical training. The instruments, flight and fire control systems remain active during the encounters with the enemies generated internally. Simulated missiles can be viewed as they fly toward the target(s), which fly programmed tactical maneuvers corresponding to generic enemy aircraft. The realism of the system is enhanced by the presence of actual aerodynamic forces and controls, and the embedded models can even provide radar displays of the visually sighted targets. Trials which will be carried out to evaluate the effectiveness of the ETS are outlined. M.S.K.

**A86-19940*#** Wichita Univ., Kans.
**DESIGNING AN ELECTRO-IMPULSE DE-ICING SYSTEM**
G. W. ZUMWALT and R. A. FRIEDBERG (Wichita State University, KS) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(Contract NAG3-284)
(AIAA PAPER 86-0545)

Basic principles and parameters for a system to deice aircraft with electromagnetic impulses are described. The physical basis for deicing by such impulses is explained, and the requirements involved in the electrodynamic design, structural dynamic design, and system design are discussed. Some manufacturing and testing problems and techniques are described. C.D.

**A86-19941#**
**THE ELECTRODYNAMIC OPERATION OF ELECTRO-IMPULSE DEICING SYSTEMS**
G. J. LEWIS (Rolls-Royce, Ltd., Derby, England) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. SERC-supported research. refs
(AIAA PAPER 86-0547)

An analysis of the transient exciting current situation is presented. The derivation of the magnetic vector potential equation and its solution using the Laplace and Hankel transforms are described. With the solution of the vector potential equation physical qualities, such as azimuthal force, and impulse, which relate to electro-impulse deicing systems performance are calculated. An experiment measuring the normal impulse on the plate is provided. The dependence of impulse on plate thickness, plate conductivity, plate separation, and discharge frequency is investigated. The theoretical and experimental data show good correlation. An example of an electro-impulse deicing system designed to the specification of the structure being deiced is given. I.F.

**A86-20036#**
**THE DAMAGE TOLERANCE APPROACH IN THE TYPE APPROVAL PROCESS**
P. FERNANDEZ-RUIZ (Transport Canada, Airworthiness Branch, Ottawa) (CASI, Annual General Meeting, 31st, Ottawa, Canada, May 28, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, March 1985, p. 3-13. refs

The optimization of maintainance procedure for type approval of commercial aircraft is studied. The damage tolerance concept, which is to predict the behavior of aircraft structures under applicable loading conditions, is based on the time it takes for cracks to appear and damage to grow. The time intervals in the maintenance program, threshold inspection level, and repeat inspection interval, are explained. The procedures to be followed by a manufacturer to achieve airworthiness certification of the aircraft are discussed. The selection of materials for design of structures that have high yield, stress, high fracture toughness, and crack growth is examined. The use of load analyses, crack growth models, test data, and numerical integration in the evaluation of aircraft structures is described. The comparison of predicted crack growth values with predefined crack growth and the development of crack growth diagrams for each structure is possible following the analyses. The damage tolerance criteria requires that the aircraft be capable of successfully completing a flight during which structural damage is possible. The testing of the ability of the pressurized fuselage to sustain impact is investigated. I.F.

**A86-20038#**
**HELICOPTER FATIGUE MONITORING USING A SINGLE CHANNEL RECORDER**
D. L. SIMPSON (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) (CASI, Annual General Meeting, 31st, Ottawa, Canada, May 28, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, March 1985, p. 30-44. refs

The use of single channel recorders and loaded transfer functions to monitor fatigue damage in CH-113 helicopters is investigated. The equipment used includes two single channel recorders for monitoring the output from strain gauges on the longitudinal pitch links on both the fore and aft rotors, and the Rainflow counting method of Hutchinson and Steinman (1980) for data compression. Techniques used to generate transfer functions are analyzed. Identification of the maneuvers which produce cycles that exceed the component endurance limit by applying flight load survey data, and the methods of treating loads above the endurance limit are described. The analyses reveal that conservative estimates of fatigue damage are calculated using transfer functions and the measured longitudinal pitch load spectrum. It is concluded that indirect monitoring of fatigue damage with single channel recorders is possible; however, improvements in instrumentation are required to provide an increase in the percentage of accurate data obtained. I.F.

**A86-20039#**
**ASSESSING COST-EFFECTIVE WEIGHT SAVING IN AIRCRAFT OPERATIONS**
D. G. PECK (Transport Canada, Ottawa) (CASI, Annual General Meeting, 31st, Ottawa, Canada, May 28, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, March 1985, p. 45-51.

Three methods of establishing cost/weight savings for aircraft are analyzed. The first method described involves measuring the value of the weight by useful load; dividing the points of useful load into the aircraft cost will establish the cost/pound value of the aircraft. A table of values of useful load for various aircraft types is provided. The second technique which calculates the value of weight by the amount of fuel saved is examined; it is observed that jets provide more savings than propeller aircraft and more flight time increases savings. The usefulness of the third method where a value is assigned to weight saving revenue purposes is revealed through an example. I.F.

**A86-20125**
**BIGGER IS BETTER - STRETCHING THE C-141 STARLIFTER**
R. A. SAPP (Lockheed-Georgia Co., Marietta, GA) Lockheed Horizons, Oct. 1985, p. 38-44.

A development history is presented for the fuselage-stretching modification undertaken in 1975 for the C-141 cargo aircraft, yielding the C-141B. The fuselage was extended 280 in by inserting a 160-in. plug ahead of the wing, and a 120-in. plug behind it, on an existing C-141A aircraft. In addition, the modification program imparted inflight refueling capabilities, and altered the spanwise wing lift distribution by changing the wing/fuselage fairing structure. The midfuselage structure was reinforced through the addition of a central longeron underneath the cargo floor. Attention is given to the splicing of the plugged fuselage section. O.C.

**A86-20155*#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**AEROELASTIC TAILORING - THEORY, PRACTICE, AND PROMISE**
M. H. SHIRK, T. J. HERTZ (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and T. A. WEISSHAAR (Purdue University, West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 6-18. NASA-supported research. refs
(AIAA PAPER 84-0982)

Aeroelastic tailoring technology is reviewed with reference to the historical background, the underlying theory, current trends, and specific applications. The specific application discussed include the Transonic Aircraft Technology program, an Advanced Design Composite Aircraft, the Wing/Inlet Advanced Development program, and the forward-swept wing. Finally, the future of aeroelastic tailoring and the development of an aeroelastic tailoring analysis and design tool under the Automated Strength-Aeroelastic Design program are examined. V.L.

**A86-20157#**

**BLENDED BLOWN FLAPS AND VECTORED THRUST FOR LOW-SPEED FLIGHT**

J. E. CARR (Grumman Aerospace Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 26-31. refs
(AIAA PAPER 84-2199)

Short take-off and landing (STOL) capability is a recurring design goal for current and future aircraft design studies to meet reduced field length requirements, provide increased stores 'bring back' capability, enhance carrier aircraft payload launch and recovery envelopes, and improve in-flight maneuvering. The Grumman Corporation has conducted a study to design and build an A-6 STOL demonstrator aircraft for the Navy that employs two-dimensional vectored nozzles and chordwise blowing for low-speed flight. If completed, this program would demonstrate operationally acceptable STOL performance with minimum loss in cruise performance. The results of a two-dimensional airfoil test determined that a plain blown flap with a large-radius, upper leading-edge blowing segment and a conventional-shaped trailing-edge section had better high-lift capability for the available blowing momentum of the design. Extensive three-dimensional wind tunnel testing verified predicted longitudinal characteristics, showed acceptable longitudinal and lateral directional control, and defined design limitations associated with the high-lift systems. Author

**A86-20158*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LABORATORY STUDY OF CABIN ACOUSTIC TREATMENTS INSTALLED IN AN AIRCRAFT FUSELAGE**

K. E. HEITMAN and J. S. MIXSON (NASA, Langley Reserach Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 32-38. Previously cited in issue 01, p. 4, Accession no. A85-10874. refs

**A86-20163#**

**PERFORMANCE OF A FORWARD SWEPT WING FIGHTER UTILIZING THRUST VECTORING AND REVERSING**

E. H. MILLER (Grumman Aerospace Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 68-75. Previously cited in issue 23, p. 3404, Accession no. A83-48344. refs
(Contract MDA903-82-C-0218)

**A86-20165#**

**FINITE ELEMENT ANALYSIS OF AN ULTRALIGHT AIRCRAFT**

T. V. BAUGHN and P. F. PACKMAN (Southern Methodist University, Dallas, TX) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, Fl, April 15-17, 1985, Technical Papers. Part 1, p. 71-78) Journal of Aircraft (ISSN 0021-8669), vol. 23, Jan. 1986, p. 82-86. Previously cited in issue 13, p. 1848, Accession no. A85-30234.

**A86-20235#**

**ENDURANCE INCREASE BY CYCLIC CONTROL**

G. SACHS and T. CHRISTODOULOU (Muenchen, Technische Universitaet, Munich, West Germany) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 58-63. refs

Applying the minimum principle, maximum endurance flight is considered as an optimal cyclic control problem with a state variable constraint. It is shown that a significant increase in the maximum endurance can be achieved by dynamic flight having an optimal cyclic control when compared to the best steady-state flight. The optimal altitude range within the flight envelope is determined. Furthermore, it is shown that the powerplant type represents a key factor when compared to other aircraft characteristics. From this, it follows that turbojet-type engines have properties that can increase endurance via cyclic control. With regard to propeller-type powerplants, however, there appears to be no or only small improvements possible for the cyclic model considered here. It is also shown that an increase in the maximum lift/drag ratio improves the cyclic control efficiency, which is more enhanced than steady-state flight efficiency. Author

**A86-20238*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**SIMULATOR EVALUATION OF A REMOTELY PILOTED VEHICLE VISUAL LANDING TASK**

S. K. SARRAFIAN (NASA, Flight Research Center, Edwards, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 80-84. Previously cited in issue 20, p. 2851, Accession no. A84-42348. refs

**A86-20822**

**ELIMINATION OF BUFFETING ON THE REAR FUSELAGE OF THE HERCULES TANKER**

D. G. MABEY (Royal Aircraft Establishment, Dynamics Laboratory, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Nov. 1985, p. 339-342.

The conversion of the Hercules aircraft for flight refuelling necessitated the installation of a small drogue box on the lower surface of the rear fuselage. This produced a long flow separation and unacceptable rear fuselage and elevator buffeting at the drogue towing speeds required. The flow separation was stabilized, and the buffeting eliminated, by the installation of strakes and the provision of a small bleed flow through the drogue box. Author

**A86-20932**

**GEOMETRY GENERATION FOR TRANSONIC DESIGN**

H. SOBIECZKY (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) IN: Advances in computational transonics . Swansea, Wales, Pineridge Press, 1985, p. 163-182. USAF-sponsored research. refs

Since demands for higher efficiency and improved performance have led to the operation of aircraft in the transonic regime, computational design procedures for both aircraft and turbomachinery have become increasingly important. The designed aircraft components have to be integrated into realistic configurations, and wind tunnel tests and refined investigations are required to predict aerodynamic performance reliably. As a result of the need of refined shape definition, the generation of geometry has become an important part of computational aerodynamics. The present paper is concerned with a flexible geometry generator which is based on a set of parameters and analytical relations. The geometry generator is to provide input data for a number of existing transonic analysis algorithms and some shock-free flow design codes. Aspects of shape generation are discussed, taking into account simple analytical relations, a fuselage geometry definition, a wing geometry definition, and wing integration to fuselage. Attention is also given to airfoil design and analysis, and computational grid generation. G.R.

**A86-21051**

**SOCIETY OF EXPERIMENTAL TEST PILOTS, SYMPOSIUM, 28TH, BEVERLY HILLS, CA, SEPTEMBER 26-29, 1984, PROCEEDINGS**

Lancaster, CA, Society of Experimental Test Pilots, 1984, 321 p. For individual items see A86-21052 to A86-21054, A86-21056 to A86-21068.

Papers are presented on supersonic conventional weapon testing, F-14A low-altitude, low-airspeed, high-angle-of-attack asymmetric thrust flight test program, initial sea trials of the AV-8B Harrier aircraft, flight tests of the helicopter pneumatic deicing system, and testing the modern composite scaled prototype. Consideration is given to F/A-18 ski jump takeoff evaluation, nonrigid airship testing, helicopter evasive maneuvering flight test, testing Canadian unique features of the CF-18, AV-8B Harrier II structural test program, probe and drogue refueling large receiver aircraft, and high speed escape systems. In addition, flight testing the fixed wing configuration of the rotor systems research aircraft, F-15 dual-role fighter flight testing, Space Shuttle development update, Space Shuttle night landing, and orbital flight test of the manned maneuvering unit are discussed. I.S.

**A86-21052**

### SUPERSONIC CONVENTIONAL WEAPON TESTING OF THE F/A-18A HORNET

J. C. STENCIL and J. PICKERAL (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 4-16.

The F/A-18A Hornet is the Navy's first tactical airplane to provide supersonic carriage and release of conventional weapons. In the course of an extensive weapon separation analysis and flight tests, the envelope expansion has uncovered interesting integration phenomena, some related to the aircraft, and some related to existing weapons hardware. The combination of an airplane with the performance capability for supersonic carriage and delivery and the extensive use of composite materials in its construction presented unique test and evaluation challenges. This paper discusses limit cycle oscillations of the wing under certain store loadings, supersonic conventional weapon separation testing of general purpose weapons, and hardware deficiencies which potentially have serious impact on the aircraft tactical envelope. The need to improve conventional weapons for the new generation of supersonic strike fighters is emphasized. Author

**A86-21053**

### F-14A LOW ALTITUDE, LOW AIRSPEED, HIGH ANGLE OF ATTACK ASYMMETRIC THRUST FLIGHT TEST PROGRAM

C. M. BAUCOM and C. CLARK (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 17-26.

The effect of asymmetric thrust (AT), due to single engine failure during low-speed, high-angle-of-attack (AOA) maneuvering, on F-14A high AOA flying qualities have been tested at low altitudes, using a F-14A No. IX highly modified aircraft with numerous special installations. Real-time F-14 simulation models, updated aerodynamic models for both the clean and external stores configurations, and a new TF30-P414A thrust model were implemented, and several low-speed aerodynamic coefficients were modified on the basis of previous flight-test results. In addition to the structured maneuvers, the effects of thrust asymmetry from both afterburner failure and full engine stalls while performing tactical fleet fighter maneuvers were tested. While AT alone did not produce disorienting departures, flight control departures could be easily induced when the uncommanded roll from thrust asymmetry was countered by natural sense lateral stick inputs away from roll. The AT contribution to such combined AT/flight control departures was the major cause of the subsequent yaw accelerations only at very high AOAs. I.S.

**A86-21054**

### AV-8B INITIAL SEA TRIALS

M. A. NYALKO and R. E. GRIMES (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 27-38.

Shored-based buildup tests, a laboratory simulation, and shipboard tests were conducted to evaluate the capabilities of the AV-8B aircraft model to operate from air-capable amphibious ships, and to compare these capabilities to those of the AV-8A aircraft. The aspects of the shipboard takeoff and landing performance, the launch and recovery techniques, the aircraft/ship interface, and the instrument approach profiles and procedures were investigated. All tests were conducted in the V/STOL configuration with gear down, ailerons dropped 15 deg, and flaps and nozzles interconnected. The tests have demonstrated an excellent capability of AV-8B to operate from a sea-based platform, with the STO performance gains of up to 42 percent increased over the AV-8A in mission payload, and an improvement of flying qualities in all flight regimes, resulting in greatly reduced pilot workload. Crosswind takeoff limitations were influenced entirely by ship's effects and were the same as those of the AV-8A. Approach profile testing to a 0.5 NM minimum showed that the AV-8B will be able to operate in all-weather conditions. I.S.

**A86-21056**

### PROGRESS REPORT - F-16 C&D TESTING

K. DWYER (General Dynamics Corp., Fort Worth, TX) and T. MESCHKO (USAF, Edwards AFB, CA) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 58-71.

The goals and some results of a three-stage F-16 Multinational Staged Improvement Program (MSIP) for the continued expansion of the F-16A/B aircraft capabilities are presented. As the ultimate goal, the future F-16C/D aircraft under development is intended to perform both the night, low-level, ground-attack missions and the all-weather, multi-target, air-to-air missions. Improved cockpit, new and improved avionics, airframe changes, and added weapon carriage are the major changes introduced during Stages I and II of the F-16 MSIP. The following systems are planned for incorporation into the F-16C/D aircraft during Stage III: the Low-Altitude Navigation and Targeting Infrared for Night system, which incorporates navigation and targeting forward looking infrared sensors and a terrain-following radar; the Advanced Medium-Range Air-to-Air Missile, as the beyond-visual-range weapon; the F-110 GE-100 engine, ASPJ equipment; the ALR-74 Radar Warning Set; the Global Positioning System; and the Precision Locator Strike System. I.S.

**A86-21057**

### F-20A TIGERSHARK PROGRESS REPORT

D. BARNES (Northrop Corp., Los Angeles, CA) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 75-100.

The progress of the F-20 flight test and marketing support efforts and of the basic F-20 design is reported. Three main topics are covered: (1) the aircraft characteristics, in particular the recently changed features, (2) selected recent flight test results, and (3) the customer demonstration and marketing-support activities. Among the special characteristics of the F-20A aircraft are an increased wing and flap area, an upgraded 18,000-lb production engine, integrated digital avionics, a first-flight-test instrument panel (FTIP) with a programmable digital display, and the second- and third-FTIP for avionics testing. The results of testing the airworthiness, the performance and flight qualities, and flight avionics performed in more than 910 test flights have verified the high degree of reliability, maintainability, and safety of the F-20A Tigershark aircraft. I.S.

**A86-21058**

### CONVENTIONAL TAKEOFF AND LANDING (CTOL) AIRPLANE SKI JUMP EVALUATION

C. P. SENN and T. A. WAGNER (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 101-117.

Ski-jump launching as an alternative to shipboard catapult launch for conventional takeoff and landing (CTOL) aircraft was evaluated by tests on an F/A-18A aircraft, using a pitch attitude-capture flyaway technique. Results of ground acceleration runs and high-angle-of-attack tests, dynamic single-engine flight characteristics, and definitions of aborted takeoff/committed to takeoff criteria are reported. In a total of 91 ski-jump launches, operated from both the 6 and 9 deg ramp, about 66 percent reduction in takeoff ground roll was obtained, compared to the normal ground takeoff. A ski-jump launch is an easier maneuver than a normal field takeoff. Any operational CTOL ski-jump aircraft should have a Head-Up Display, nosewheel steering, stability augmentation in all axes, and an accurate, repeatable flight control trim system. The general arrangement and dimensions of the test ski-jump equipment are included. I.S.

**A86-21059**

### NON-RIGID AIRSHIP TESTING

L. D. WHITMER and K. BEEKS IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 118-127.

The flying qualities and performance of a lighter-than-air aircraft, the Patrol Airship Concept Evaluation (PACE) test airship, designated AI-500, were evaluated. NASA's Ames, in conjunction with Systems Technology, provided the instrumentation for dynamic tests and propeller thrust measurements. The results indicate that the AI-500 has a potential for use in maritime patrol missions. However, the conventional control system is inadequate for long-endurance or heavy-weather missions due to high control forces in maneuvering flight, and a requirement for the pilot to continually monitor the controls to maintain proper altitude and heading alignment. The vectored thrust did provide a VTOL capability, but not an adequate rearward vector angle and lateral control in the hovering environment. An analysis indicated that these deficiencies were correctable. I.S.

**A86-21060**

### TESTING CANADIAN UNIQUE FEATURES OF THE CF-18 - THE FIRST YEAR

G. M. LACROIX (Aerospace Engineering Test Establishment, Canada) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 150-163.

The initial Weapons Clearing Program (WCP) of Canada's multirole CF-18 fighter was tested, including the 19 tube LAU-5003 rocket launcher and 2.75-in. CRV-7, the BL-755 cluster bomb, and the SUU-5003 training dispenser with four CRV-7's and six Modular Practice Bombs. The major program phases consisted of the flutter, flying qualities, cruise performance, the separation/jettison, and the rocket compatibility/accuracy tests. The results indicate that all objectives of the CF-18 initial WCP were achieved. Appropriate limits have been established to ensure the successful employment of the WCP weapons, and the follow-on testing has been identified to further enhance the capabilities of the CF-18. Diagrams of the CF-18 flutter test configurations, flying qualities test configurations, and the flutter analysis system are included. I.S.

**A86-21061**

### STRUCTURAL DEMONSTRATION OF THE AV-8B HARRIER II

J. C. JACKSON (McDonnell Aircraft Co., St. Louis, MO) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 164-175.

Structural demonstration of the AV-8B Harrier II, an aircraft that is 26 percent advanced composite material (graphite material filaments bonded together in a matrix of epoxy), and the results of the ground- and flying-tests are presented. The ground fatigue tests on the airframe had no failures, and the parts of the aircraft made from composite materials did extremely well. Five different configurations were tested in the flight test program, ranging from a clean aircraft to one carrying four 1000-lb bombs. The low-altitude and high-speed handling qualities of the aircraft were satisfactory. There were no major structural failures encountered nor load limits exceeded. A unique method of instrumentation was developed for this aircraft, in which the measurands were sandwiched in between layers of the composite materials as they were put together. The diagrams of the AV-8B aircraft, its control surface loads instrumentation, the test site communication system, as well as the structural demonstration points are included. I.S.

**A86-21062**

### PROBE AND DROGUE REFUELLING LARGE RECEIVER AIRCRAFT

J. A. BROWN (Aeroplane and Armament Experimental Establishment, Boscombe Down, England) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 176-190.

The probe- and-drogue refueling techniques of large fighter-type aircraft, practiced in the 1950's and 1960's and applied again during the Falklands' crisis, are reviewed. The trials method involved and the problems of performance (in particular, in cases when the envelope overlap is small, and the refueling must take place at altitudes below 10,000 ft, where the worst of the weather is found) are discussed in detail. Special attention is given to the aspects of handling a large receiver and the problems connected with pilot-induced oscillations and heavy controls (heavy ailerons, elevators, etc.) in the situations where lateral position must be controlled within 9 inches with minimal lateral motion at the time of contact. The effect of receiver's bow wave on the drogue is considered. Finally, the potential dangers of propellers in the C2, Transall, and C130 probe and drogue receivers are examined. A list of recommendations is given concerning characteristics and features of an ideal probe-and-drogue large receiver vehicle. I.S.

**A86-21063**

### ESCAPE SYSTEMS TESTING

J. B. MCDONALD and D. GRAGG (USAF, Holloman AFB, NM) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 191-206. refs

The escape system's (ES's) aspects of flight testing, in particular the problems encountered in the dynamic speed ranges above 600 KEAS, are presented. The development history of ES in the last 20 years led to the introduction of an encapsulated ES and the new Advanced Concept Ejection Seat (ACES)-II. Problems posed to the ESs by helicopter blades are considered. Special problems involved in high-speed escape (up to 700 KEAS), where human tolerance may be exceeded due to the explosive catapult charge, windblast, and acceleration, resulting in disabling spine injuries, are discussed. A new generation of ejection seats, introduced by an advanced development program, the Crew Escape Technology (CREST), is examined. The CREST seats will enable a safe escape at 700 KEAS, needing only 75 ft at 300 KEAS and a flight path angle of 30 deg, and will have advantageous restraining capability. In addition, a new concept in sled design, the Multi-Axis Seat Ejection Sled, is discussed. I.S.

**A86-21064*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### FLIGHT TESTING THE FIXED WING CONFIGURATION OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT (RSRA)

G. W. HALL (NASA, Ames Research Center, Moffett Field, CA) and P. M. MORRIS (U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 209-223. Previously announced in STAR as N85-34135.

The Rotor Systems Research Aircraft (RSRA) is a unique research aircraft designed to flight test advanced helicopter rotor system. Its principal flight test configuration is as a compound helicopter. The fixed wing configuration of the RSRA was primarily considered an energy fly-home mode in the event it became necessary to sever an unstable rotor system in flight. While it had always been planned to flight test the fixed wing configuraion, the selection of the RSRA as the flight test bed for the x-wing rotor accelerated this schedule. This paper discusses the build-up to, and the test of, the RSRA fixed wing configuration. It is written primarily from the test pilot's perspective. Author

**A86-21065**
**F-15 DUAL-ROLE FIGHTER FLIGHT TESTING**
D. C. SPENCER (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 224-236.

A development test and evaluation effort on the F-15E Dual-Role Fighter (DRF) is reported. The F-15E, which as a derivative of the current F-15 aircraft, is a projected long-range aircraft for the air-to-ground (A/G) as well as the air-to-air (A/A) missions. The aspects of the F-15 derivative (equipped with Conformal Fuel Tanks and five-station weapon carriage), fighter evaluation, the scope of the testing, the performance results, specific flying qualities, and avionics evaluation are discussed. The improvements planned for the F-15E include an upgraded radar, programmable armament control set, and Advanced Medium-Range A/A Missile capability, as well as Low Altitude Navigation Infrared System for Night pods, HRR equipment, and expanded weapons capability. The crew station design has been reconfigured, to incorporate the state-of-the-art avionics, and tested successfully by a high-fidelity flight simulator. The flight tests have demonstrated that the F-15E DRF, while retaining the superior A/A capability of the F-15, will be capable of the deep strike/interdiction missions at night and/or under the weather. I.S.

**A86-21306**
**BASIC AIRCRAFT PERFORMANCE**
S. A. POWERS (Fairchild Republic Co., Conceptual Systems Development Directorate, Farmingdale, NY) Duxbury, MA, Kern International, Inc., 1984, 238 p.

A set of eight computer programs which can be used to generate accurate estimates of the performance of aircraft, both on prescribed missions and in maneuvering flight at prescribed conditions, is described. A sophisticated, state of the art drag prediction method, a thrust/fuel flow input and evaluation program, and a simple method of describing complex missions are included in the set of programs. With this computing system, it is possible to go from a three view drawing of an aircraft and a table of thrust/fuel flow data for the engine to a completed performance envelope and a mission performance description in two hours elapsed time. The use of each program is discussed, and an example of the use of each option is provided. The methods used in the programs are described, and each variable used is identified. C.D.

**A86-21712**
**SF-340 AIRFOIL STRUCTURE - A UNIQUE APPROACH**
P. V. OLIVA (Fairchild Republic Corp., Farmingdale, NY) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 116-124.

The major effort was directed at the fabrication process development for a generic aileron. Full size feasibility structural shells were produced and used to develop efficient fabrication techniques. These were utilized in the successful production of a generic monocoque shell. A complete aileron assembly was produced by installing hinge fittings and end ribs to the shell and the structure was subjected to static test. No discernible damage was detected at 150 percent of design ultimate load (225 percent of limit load) and the strain values were in excellent agreement with prediction. The hollow shell structure, which consists of an inner and outer graphite/epoxy face sheets sandwiched on a Nomex honeycomb core is shown. This new unique approach for an all composite aileron is currently in production on the commercial aircraft designated as the SF-340. Author

**A86-21897#**
**DESIGNING AN AIRLIFTER - MCDONNELL DOUGLAS'S C-17**
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Jan. 1986, p. 66-68, 70.

A design development history is presented for the C-17 military airlifter, whose performance requirements have been characterized as a synthesis of the external dimensions of the C-141B, the cargo capacity of the C-5, and the short/soft airfield operations capabilities of the C-130. Emphasis is given to the ground handling features of the C-17, whose cargo ramp can bear as great a load as the payload volume's main floor. Powered lift for STOL is effected through the direction of the four engines' exhausts onto the extended, double slotted flaps. Low life cycle costs were paramount in the course of C-17 design; for the first time, a military aircraft will be covered by warranties for reliability, maintainability, and mission completion. O.C.

**A86-22098#**
**F-14 RE-ENGINING WITH THE F110 ENGINE**
O. T. CASTELLS (General Electric Co., Evendale, OH) and J. T. STRONG, JR. (Grumman Aerospace Corp., Bethpage, NY) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 8 p.
(ASME PAPER 85-GT-184)

The advantages of re-engining the F-14 aircraft with the F110 engine is presented. The areas of improvement and the engine development philosophy are explained. A summary description of the pertinent engine design features of the F110 are presented. The flight test results on inlet/engine compatibility, afterburner operation, airplane performance, and maintainability/reliability/durability are interpreted. Finally, a description of the proposed version of the F110 engine for the F-14 is presented. Author

**A86-22112#**
**THE KC-135/CFM56 RE-ENGINE PROGRAM**
P. H. PACKER and M. P. GOODMAN (Boeing Military Airplane Co., Wichita, KS) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 6 p. refs
(ASME PAPER 85-GT-211)

This paper reviews the preliminary studies that led to the KC-135/CFM56 Re-Engine Program and discusses the motivation for re-engining an aircraft, designed in the mid 1950s, with a modern high bypass turbofan. The selected engine, the CFM56-2B-1. The other major aircraft modifications are described. The KC-135R test program methods and results are addressed with particular attention given to engine and aircraft performance. The overall benefits of the program relating to mission capability, environmental impact, and cost are also presented. Author

**A86-22127#**
**THE F-16 COMMON ENGINE BAY**
C. E. PORCHER ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 8 p.
(ASME PAPER 85-GT-231)

The aircraft-engine interfaces of the F-16 fighter's Common Engine Bay (CEB) are compatible with the current F100-PW-200 engine or either of the F110-GE-100 and F100-PW-220 engines of the U.S. Air Force's Alternate Fighter Engine competition. Simple kits allow changes among any of these three engines to be made in the field. Attention is presently given to the concept development history and program management aspects of the CEB, as well as the design features and control requirements of engine installation. O.C.

**A86-22131#**
**XB-70 STRUCTURES AND MATERIALS ADVANCEMENTS**
L. M. LACKMAN (Rockwell International Corp., El Segundo, CA) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 3-1 to 3-13. refs

The XB-70 was developed in the late 1950's. It was designed for intercontinental range at a sustained Mach 3 flight velocity while flying at an operational altitude of 70,000 feet. This environment required the establishment of many new criteria for structural design. Demanding and expansive structures/materials developments were vital in attaining the design goals. The structural configuration employed and its analysis and testing is presented.

The development of brazed steel honeycomb sandwich for use in shells and wing structures is described. New corrosion-resistant steel and titanium alloys were developed and are reviewed. The application of welded butt joints in steel honeycomb is discussed. The contributions of the XB-70 to the structural design of the following generation of high-speed aircraft are covered. Author

**A86-22132#**
**STRUCTURAL EVOLUTION B-58 TO F-16**
E. M. PETRUSHKA and J. W. MORROW (General Dynamics Corp., Fort Worth, TX) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 4-1 to 4-6.

The evolution from the B-58 'bonded bomber', where extreme emphasis was placed on structural performance, to the F-16 aircraft, based on the USAF Aircraft Structural Integrity program philosophy, is described. A transitional stage between these two aircraft designs is represented by the F-111, which utilized high-strength materials and bonded structure technology and in which the original steel design as augmented with a boron doubler, which reduced stress levels in wing pivot fittings. The F-16 is the first USAF aircraft to be designed, from the start, to meet durability and damage tolerance requirements under the acceptance methods of MIL-STD-1530A. The paper includes structure diagrams and design specifications of F-16 aircraft features. I.S.

**A86-22133#**
**STARSHIP 1**
E. H. HOOPER (Beech Aircraft Corp., Wichita, KS) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 6-1 to 6-6.

The application of advanced composite materials in the construction of the Beechcraft Starship I is reviewed. The material systems utilized are described as are the specific structural concepts for typical airframe components. The paper discusses the manufacturing processes briefly. Author

**A86-22165#**
**A CASE STUDY IN FATIGUE LIFE EXTENSION - THE MAIN SPAR OF RAAF MIRAGE IIIO WINGS**
J. Y. MANN (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) and K. J. KENNEDY (Commenwealth Aircraft Corp., Ltd., Melbourne, Australia) Institution of Engineers , Mechanical Engineering Transactions (ISSN 0727-7369), vol. ME10, July 1985, p. 90-97. refs

The operation of the Australian and Swiss Air Forces' Mirage III aircraft beyond their original fatigue design or certification lives, without increasing the risk of structural failure, prompted a fatigue life extension program whose task was complicated by the discovery of fatigue cracks at the bolt holes of the wings' main spar. A comprehensive fatigue testing program was undertaken to extend the wings' service life on the basis of interference-fit bushes. The net cost savings of this program, which extended to inspection, manufacturing and installation procedures, represented savings of about $19 million Australian by comparison with the alternative of purchase of new wings from the manufacturer. O.C.

**A86-22261**
**CANARD MIRAGE ON TEST**
W. SPYCHIGER (Swiss Defence Technology and Procurement Agency, Switzerland) Flight International (ISSN 0015-3710), vol. 128, Dec. 14, 1985, p. 38-40.

A flight test program is being conducted by the Swiss Air Force to determine whether nose strake/canard control surface additions to its fleet of Mirage IIIs are a cost-effective means of extending high angle of attack maneuverability, and therefore of allowing retention of the Mirage III through the 1990s. Attention is given to gun firing certification test results for aircraft of this type with and without canards and strakes, as well as to experience with Sidewinder missile separation tests. A small canard is used which requires no airframe structural modification. Low speed maneuverability and instantaneous turn rate are significantly improved by canards. O.C.

**A86-22262**
**OLD FIGHTERS - NEW TARGETS**
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Jan. 1986, p. 4-8.

Full scale target drones derived from mothballed combat aircraft by means of a conversion program that furnishes continuous remote control, destruct, smoke emission visual acquisition and target scoring systems provide the most realistic training of combat pilots for confrontation with prospective threats. F-86, T-33, and F-104 single seat aircraft, as well as B-47 bombers, have been employed in this capacity. Attention is presently given to the conversion process to which F-100 fighters are subjected, and their remote control system's architecture. O.C.

**A86-22263**
**EXPLORING THE UNKNOWN WITH UNMANNED AIRCRAFT**
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Jan. 1986, p. 22-27.

An evaluation is made of the operational and economic rationales for the use of remotely piloted research vehicles (RPRVs) in the study of novel aerodynamaic configurations and flight control techniques. These 'undersize' aircraft can be manufactured for a fraction of the cost of a full sized, piloted research vehicle, and can be used to obtain high quality flight test data in extreme portions of the given flight envelope without endangering a test pilot. High-G maneuvering beyong the limits of human tolerance can therefore be routinely studied by an RPRV such as the Highly Maneuverable Aircraft Technology vehicle. Spin phenomenon research and oblique wing RPRVs have also been successfully employed. O.C.

**A86-22378**
**AV-8B DESIGN FOR MAINTAINABILITY**
R. J. ANDERSON (McDonnell Aircraft Co., St. Louis, MO) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 28-33.

Methods, procedures, and design features used to create a maintainable and effective AV-8B light attack Vertical/Short Takeoff and Landing (V/STOL) aircraft for operations from all classes of carriers, VTOL ships/sea platforms, shore bases, and forward sites are identified. A comparison with AV-8A, stressing areas of improvement, is made. The AV-8B maintainability requirements are given along with the highlights of efforts to meet those requirements. The use of high yield technology in the AV-8B is discussed, as are improvements in structure, the landing gear system, the fuel system, and the armament system. The results of Maintenance Engineering Inspection and of Full Scale Development Evaluation are described. C.D.

**A86-22400**
**F/A-18 HORNET - RELIABILITY DEVELOPMENT TESTING**
W. R. ROGGER (McDonnell Aircraft Co., St. Louis, MO) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 373-378.

The F/A-18 reliability program established reliability development testing (RDT) as a firm requirement. The F/A-18 dedicated RDT had the objective to improve future hardware reliability by timely identification of problems and verification of corrective actions. The Operational Mission Environment (OME) was converted to extreme conditions during RDT to accelerate failure mechanisms without inducing nonrepresentative failure modes. It is pointed out that the original F/A-18 requirements specified that reliability development tests for avionics be conducted on all customer furnished equipment (CFE). Attention is given to details regarding the F/A-18 Avionic Equipment Reliability Test, OME study results, test environments, application to preplanned product improvement, and lessons learned in connection with the F/A-18 RDT. G.R.

**N86-16211#** National Aerospace Lab., Amsterdam (Netherlands). Hoofdafd. Stromingen.
**FATIGUE LIFE MONITORING OF AIRCRAFT**
J. B. DEJONGE 27 Oct. 1983 10 p In DUTCH; ENGLISH summary Presented at Netherlands Association of Aeronautical Engineers, 1 Dec. 1983
(NLR-MP-83069-U; B8568105) Avail: NTIS HC A02/MF A01

Methods for monitoring fatigue loads on aircraft structures are presented. As the actual service life deviates appreciably from design load spectrum assumptions, a reassessment of safe service life and inspection schedules are shown to be necessary. Simple counting accelerometer systems; multiparameter recording systems; and direct strain monitoring systems are discussed. Examples of combat aircraft and civil transport aircraft are presented. The interpretation of recorded loads in terms of accumulated fatigue damage is considered. Author (ESA)

**N86-16653#** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
**AIRWORTHINESS FLIGHT TEST PROGRAM OF AN AIRCRAFT EQUIPMENT FAIRING**
V. R. MILLER and T. P. SEVERYN (4950th Test Wing, Wright-Patterson AFB, Ohio) *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 2 p 69-75 Jun. 1985 refs
Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 01C

The results of an airworthiness flight test program of an aircraft equipment fairing are given. The objective of the tests was to insure the airworthiness of the aircraft with the installed fairing. The tests were conducted to determine the structural integrity of the modifications and their effects on the aircraft handling qualities. The tests were extended to allow more detailed data acquisition and analysis due to the problems encountered with flow separation, aerodynamic buffeting and noise-induced fatigue. The test indicated that the airspeed envelope of the aircraft be restricted while the fairing was installed, and that structural modifications to portions of the aircraft be made. Rigid inspection requirements were levied after each flight to detect any structural damage. Author

**N86-17297#** Fuji Heavy Industries Ltd., Utsunomiya (Japan).
**APPLICATION OF COMPUTATIONAL AERODYNAMICS TO WING DESIGN**
M. MAKADATE *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 271-278 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Recent progress in Computational Aerodynamics has enabled the engineers of aircraft manufacturers to utilize transonic aerodynamic analysis programs in designing wings. Effectiveness of control surfaces (spoiler, aileron), which is greatly influenced by the characteristics of the wing, is an important problem. This paper introduces application of transonic aerodynamic analysis programs to the computation of control surface effectiveness. B.W.

**N86-17298#** National Aerospace Lab., Tokyo (Japan).
**A NUMERICAL SOLUTION OF THE TRANSONIC INTEGRAL EQUATION AND ITS APPLICATION TO THREE-DIMENSIONAL TRANSONIC WING DESIGN**
S. TAKANASHI *In its* Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 279-292 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A numerical solution of the transonic integral equations is presented for three-dimensional transonic wing design. The objective of the design problem is to determine the wing geometry which realizes a prescribed pressure distribution on the wing surface. This boundary value problem can be formulated by the transonic integral equations with artificial viscosity terms. The resulting integral equations are simplified by introducing an approximate function for the space velocity distribution which reduces the three-dimensional problem to a two-dimensional one. The uniqueness of solution is guaranteed by imposing an additional condition, i.e., the closure condition at the trailing edge. To facilitate numerical evaluation of the definite integrals the wing surface is divided into a number of small rectangular panels. As a result, the singular integral equations are converted to a system of linear equations which can easily be solved by standard numerical techniques. An extension of the integral equation method to more general and versatile design procedure is described, and some of the design results for a transonic sweptback wing with an isobar pattern are also presented. Author

**N86-17299#** Mitsubishi Heavy-Industries Ltd., Tokyo (Japan).
**A WING DESIGN BASED ON THE THREE-DIMENSIONAL TRANSONIC INVERSE METHOD AND THE COMPARISON WITH THE WIND TUNNEL TESTING DATA**
S. TATSUMI and S. TAKANASHI *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 293-304 1984 refs In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Along with the recent progress in computational aerodynamics, aircraft designers have paid great attention to inverse methods. Inverse methods, which determine wing geometries under prescribed target pressure distributions, are considered important design techniques because of the applicabilities of experience and knowledge of aircraft designers. Although several two-dimensional methods have already been established, there exist only a few reports about three-dimensional transonic inverse methods, and the three-dimensional technique has not been established yet. This report describes wing design by the three-dimensional transonic inverse method using the integral equation formulation which was developed by one of the authors. The method has the great advantage that various flow-solvers can be applied. Also wind tunnel testing was conducted with the design wing to investigate the capability of the method. The comparison of design and test results shows a good agreement and the method proves to be very effective in three-dimensional transonic wind design. Author

**N86-17336** Royal Aircraft Establishment, Farnborough (England).
**STANDARDISED FATIGUE LOADING SEQUENCES FOR HELICOPTER ROTORS (HELIX AND FELIX). PART 1: BACKGROUND AND FATIGUE EVALUATION**
P. R. EDWARDS, comp. and J. DARTS, comp. 14 Aug. 1984 115 p refs 2 Vol.
(RAE-TR-84084; RAE-MAT/STRUCT-101-PT-1; ICAF-1442-PT-1; NLR-TR-84043-U-PT-1; LBF-FB-167-PT-1; IABG-TF-1425-PT-1; BR95787) Avail: NTIS HC A06/MF A01

The background of the Helix and Felix standard loading sequences for the main rotors of helicopters with articulated and semirigid rotors respectively is outlined. The loading standards provide a convenient tool for providing fatigue data under realistic loading, which can immediately be compared with other data, and can be used to provide design data. Helix and Felix statistical content according to different counting methods and the results of fatigue tests used to assess them are presented. Author (ESA)

**N86-17337** Royal Aircraft Establishment, Farnborough (England).
**STANDARDISED FATIGUE LOADING SEQUENCES FOR HELICOPTER ROTORS (HELIX AND FELIX). PART 2: FINAL DEFINITION OF HELIX AND FELIX**
P. R. EDWARDS, comp. and J. DARTS, comp. 14 Aug. 1984 122 p refs 2 Vol.
(RAE-TR-84085; RAE-MAT/STRUCT-100-PT-2; ICAF-1442-PT-2; NLR-TR-84043-U-PT-2; LBF-FB-167-PT-2; IABG-TF-1425-PT-2; BR95846) Avail: NTIS HC A06/MF A01

Full length and shortened versions of the Helix and Felix standard loading sequences for rotors of helicopters with articulated and semirigid rotors respectively are presented. The standards provide a convenient tool for providing fatigue data under realistic

loading, which can immediately be compared with other data, and can be used to provide design data. The method of generation is extremely simple, although a considerable amount of data is required for the generation algorithm. A FORTRAN program and complete data tables in the correct format are given.
Author (ESA)

**N86-17338*#** National Aeronautics and Space Administration, Washington, D.C.

**AERODYNAMIC DESIGN TRENDS FOR COMMERCIAL AIRCRAFT**

R. HILBIG and H. KOERNER Jan. 1986 54 p refs Transl. into ENGLISH of conference paper "Aerodynamische Entwicklungsrichtungen fuer Verkehrsflugzeuge" rept. DGLR-84-082 presented at the German Aerospace Society Annual Convention, 1984 p 1-53 Convention held in Hamburg, West Germany, 1-3 Oct. 1984 Original language document was announced in IAA as A85-40302 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77976; NAS 1.15:77976) Avail: NTIS HC A04/MF A01 CSCL 01C

Recent research on advanced-configuration commercial aircraft at DFVLR is surveyed, with a focus on aerodynamic approaches to improved performance. Topics examined include transonic wings with variable camber or shock/boundary-layer control, wings with reduced friction drag or laminarized flow, prop-fan propulsion, and unusual configurations or wing profiles. Drawings, diagrams, and graphs of predicted performance are provided, and the need for extensive development efforts using powerful computer facilities, high-speed and low-speed wind tunnels, and flight tests of models (mounted on specially designed carrier aircraft) is indicated. T.K.

**N86-17340#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.

**CRITICAL ANALYSIS OF TURBULENCE RESTITUTION FROM ACCELERATION MEASUREMENTS [ANALYSE CRITIQUE DE LA RESTITUTION DE LA TURBULENCE A PARTIR DE MESURES D'ACCELERATION]**

G. COUPRY Jan. 1985 34 p refs In FRENCH
(Contract STPA-84-95015)
(ONERA-RT-3/3567-RY-C40-R) Avail: NTIS HC A03/MF A01

Civil aircraft acceleration data were collected for an atmospheric turbulence data bank. Differences observed among the different types of aircraft are analyzed. The error analysis shows that these differences are not related to turbulence scale. However, the coefficients used to compute turbulence from acceleration appear inadequate. The Poisson statistical law is confirmed as suitable to describe turbulence distribution. Author (ESA)

**N86-17341#** Bundesanstalt fuer Flugsicherung, Frankfurt am Main (West Germany). Buero der Nachrichten fuer Luftfahrer.

**ENVIRONMENT-FRIENDLY PROPELLER AIRCRAFT WITH A MAXIMUM WEIGHT OF 5700 KG, AND MOTOR GLIDERS: PUBLICATION OF THE NOISE VALUES [UMWELTFREUNDLICHE PROPELLERFLUGZEUGE BIS 5700 KG HOECHSTMASSE UND MOTORSEGLER: VEROEFFENTLICHUNG DER LAERMWERTE]**

31 Oct. 1983 25 p In GERMAN
Avail: NTIS HC A02/MF A01

The noise values (status October 31, 1983) of all prototypes and series of propeller aircrafts and motor gliders fulfilling the standard MfLII-47/75 or the noise protection requirements for aircraft LSL (April 23, 1981) are listed. Equipment, maximum permissible cruising power, maximum permissible number of revolutions, initial mass, temperature corrected noise level, power correction value, certified noise level, and noise threshold are given. Author (ESA)

**N86-17342#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

**DAMAGE-TOLERANT AIRCRAFT DESIGN**

H. P. VANLEEUWEN 23 Jan. 1984 30 p refs Presented at 5th European Conference on Fracture, Lisbon, Portugal, 17-21 Sep. 1984
(NLR-MP-84005-U; B8568522) Avail: NTIS HC A03/MF A01

Actions to be taken to realize a damage-tolerant aircraft structure and to have it certified are listed. Studies to define aircraft usage, missions; develop load spectra, sequences; select critical locations for an evaluation; develop stress spectra for those locations; determine environmental conditions for those locations; compile crack growth data for each material and environment; compile fracture toughness data; produce crack growth curves; determine residual strength; decide on inspection techniques; determine detectable crack length; and decide on inspection intervals are summarized. Full scale tests on an F-28 aircraft wing are described. Author (ESA)

**N86-17343#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**HELICOPTER-SHIP QUALIFICATION TESTING**

R. FANG, T. J. HOEKSTRA, and C. F. G. M. HOFMAN 18 Jun. 1984 19 p Submitted for publication
(NLR-MP-84062-U; B8568102) Avail: NTIS HC A02/MF A01

Helicopter-ship qualification tests are reviewed. The total program comprises wind-tunnel tests on a scale model of the ship, full scale wind climate tests on board the ship, shore-based helicopter flight tests in the low speed region, and helicopter flight tests on board the ship. The program leads to a safe and optimum operational availability of the helicopter on board the ship in terms of take-off, landing and deck handling capabilities as a function of relative wind and sea-state. Author (ESA)

**N86-17344#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**DESIGN AND FABRICATION OF AN ADVANCED COMPOSITE CELLULAR WING BOX**

G. ROMEO (Polytecnico di Torino, Italy) and W. H. M. VANDREUMEL 1984 23 p refs
(VTH-LR-315) Avail: NTIS HC A02/MF A01

A cellular integral structure was designed for the upper and lower panels of a wing box in order to realize a ribless structure. A small panel was manufactured and tested under uniaxial compression. A wing box (length 1300mm) was manufactured. Author (ESA)

**N86-17345#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**LECTURE NOTES ON FATIGUE, STATIC TENSILE STRENGTH AND STRESS CORROSION OF AIRCRAFT MATERIALS AND STRUCTURES. PART 2: FIGURES**

J. SCHIJVE Aug. 1983 121 p refs
(VTH-LR-360-PT-2; B8563474) Avail: NTIS HC A06/MF A01

Graphs, photographs, and figures from a report on aircraft materials and structures tests are presented. Author (ESA)

**N86-17346#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**OPERATIONAL APPLICATION OF THE STALINS METHOD FOR MEASURING TAKE-OFF AND LANDING TRAJECTORIES**

C. G. KRANENBURG, A. POOL, and A. J. L. WILLEKENS 15 Apr. 1983 55 p refs Revised
(Contract NIVR-1899)
(NLR-TR-83010-U; B8569023) Avail: NTIS HC A04/MF A01

The STALINS method to calculate the trajectories from the outputs of an inertial sensing system is described and compared with results obtained from onboard cameras and a radio altimeter from 200 takeoff and landing flight tests. The comparison shows that the STALINS method is at least as accurate as the other methods and meets its design goals. Author (ESA)

**N86-17347#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**THREE-DIMENSIONAL FLIGHT-PATH RECONSTRUCTION BY MEANS OF SPLINE APPROXIMATION**

M. R. BEST 30 Jul. 1985 67 p refs
(Contract NIVR-1816)
(NLR-TR-83091-U; B8568391) Avail: NTIS HC A04/MF A01

A method to reconstruct the flight path of a symmetric flight, by representing this path by a set of splines, was applied to a three-dimensional flight over a rotating Earth. Results are comparable in accuracy and computing time to the Kalman (square root information) smoother, but reduction in computing time seems feasible. Author (ESA)

**N86-17348#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

**ESTIMATION OF LOAD EXCEEDANCES OF AN AIRCRAFT UNDER CARRIAGE WITH NONLINEAR PROPERTIES EXCITED BY RANDOM RUNWAY UNEVENNESS**

R. NOBACK 20 Mar. 1984 94 p refs
(Contract NIVR-1947)
(NLR-TR-84030-U; B8568529) Avail: NTIS HC A05/MF A01

Methods to describe a landing gear with nonlinear properties excited by random runway unevenness during taxiing were investigated. Calculations were compared to measured results from an analog computer simulation. The mean behavior, standard deviations, and power spectra can be described with a classic type of equivalent gain. Load exceedance curves can be approximated fairly well with conditional equivalent gains that depend on the output load level. Author (ESA)

**N86-17349#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**OPTIMIZATION IN DESIGN PROCESSES: AN INFORMATICS POINT OF VIEW**

R. F. VANDENDAM, J. W. BOERSTOEL, and H. A. M. DANIELS 3 Aug. 1984 33 p refs Presented at International Conference on Inverse Design Concepts in Engineering Science (ICIDES), Austin, Tex., Oct. 1984 Submitted for publication
(NLR-MP-84074-U; B8569324) Avail: NTIS HC A03/MF A01

Optimization system development and the potential of mathematical optimization techniques in aeronautical engineering are discussed. The main requirements to be met by a general-purpose optimization system are given. Implementation is described, and examples of applications are presented. Author (ESA)

**N86-17350#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.

**STRATEGIES FOR DYNAMIC MODELING OF A HELICOPTER STRUCTURE**

S. DURAND and V. YANA 1985 12 p refs Presented at 11th European Rotorcraft Forum, London, England, 10-13 Sep. 1985
(SNIAS-852-210-101) Avail: NTIS HC A02/MF A01

Helicopter dynamic modeling problems are studied using three principles: divide difficulties, correlate with test and simplify reality. The analytical procedures that were used include the finite element method, modal analysis, harmonic analysis and transient analysis. The method is applied to the tail section of the Ecureil helicopter. Good correlation between natural frequency modes as measured and calculated is obtained over nine vibrating modes. The forced response calculations allowed to find a solution to a problem of unbalance excitation caused by the tail rotor. Author (ESA)

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-19571**

**LASER SYSTEMS FOR USE WITH AIRBORNE PLATFORMS**

J. JEPSKY (Associated Controls and Communications, Inc., Salem, MA) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 435-442.

The use of pulsed gallium arsenide and yttrium-aluminum-garnet laser systems for profiling, altimetry, photogrammetric control, collision avoidance, and shipboard landing systems is examined. Laser transmitters operate at pulse rates up to 4 KHz, at peak power outputs up to 100 watts, and a 10-50 nanosecond pulse width. The techniques utilized by the rangefinders for the measurement circuitry are discussed. In order to evaluate the accuracy of the range measurements the signal-to-noise ratio is calculated. Operation of the laser system for profiling, with a control console and a single board computer is analyzed. Examples of profiles obtained using the laser system are presented. The SKEET Delivery System and the SKEET Delivery Vehicle Assembly are described. I.F.

**A86-19576**

**AIRBORNE RECONNAISSANCE VIII; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, AUGUST 21, 22, 1984**

P. HENKEL, ED. (General Dynamics Corp., Fort Worth, TX) and F. R. LAGESSE, ED. (McDonnell Aircraft Co., St. Louis, MO) Meeting sponsored by SPIE - The International Society for Optical Engineering. Bellingham, WA, SPIE - The International Society for Optical Engineering (SPIE Proceedings. Volume 496), 1984, 186 p. For individual items see A86-19577 to A86-19602.
(SPIE-496)

Various papers on sensors and ancillary equipment, technological advances, development and testing, and intelligence extraction and exploitation in airborne reconnaissance are presented. The topics discussed include: the CA-810 modern trilens camera, PC-183B standoff imaging system, ruggedized MMW radiometer sensor for surveillance applications, application of biocular viewers to airborne reconnaissance, KA-102 film/EO standoff system, KS-146A camera development and flight test results, electrooptical imaging for film cameras, and new generation advanced IR linescan sensor system. Also addressed are: evolution of real time airborne reconnaissance, computer-controlled operation of reconnaissance cameras, miniature focus sensor microprocessor-controller autofocus system, camera flight tests and image evaluation, LM-230A cost-effective test system, information management for tactical reconnaissance, performance modeling of infrared linescanners and FLIRs, USAF tactical reconnaissance - Grenada, sensor control and film annotation for long-range standoff reconnaissance, laser beam recording on film, meteorological effects on image quality, and optimization of photographic information transfer by CRT. C.D.

**A86-19577**

**THE CA-810 - A MODERN TRI-LENS CAMERA**

G. LEWIS (Recon/Optical, Inc., Barrington, IL) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellinghem, WA, SPIE - The International Society for Optical Engineering, 1984, p. 6-12.

Advances in electronic technology have allowed the camera designer more latitude in choosing how each camera function is to be performed. This paper describes the CA-810 camera design, showing how modern technology allows the configuration of a camera to meet both high airborne performance and reliability. The CA-810 camera uses three 80-mm, f/2.0 lenses and two prisms to provide over 140 deg across the line of flight by 47 deg in the line of flight coverage. It is similar in general arrangement to the KA-63 camera produced in 1963. The CA-810 camera is capable of operation at cycle rates up to 12.6 frames/s. Results of tests on the CA-810 camera are vgiven, demonstrating the effectiveness of the use of modern technology in the design of a new low altitude, high cycle rate camera. Author

**A86-19578**

### PC-183B STANDOFF IMAGING SYSTEM

H. J. FREDRICKSON (Itek Corp., Optical Systems Div., Lexington, MA) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 13-18.

Itek has recently completed a program to supply long range oblique photography (LOROP) cameras for a nose installation in an F-104 aircraft. The camera, designated PC-183B, is a derivative of a configuration presented at the June 1980 SPIE show. The PC-183B camera features reflective optics, internal two-axis stabilization, and a unique air capstan. Author

**A86-19580**

### APPLICATION OF BIOCULAR VIEWERS TO AIRBORNE RECONNAISSANCE

H. G. ELDERING (Baird Corp., Government Systems Div., Bedford, MA) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 27-30.

Biocular viewers permit magnification of small areas without optical distortion and produce an image that can be viewed with both eyes. Current applications range from biocular viewing of driftsights, image intensifiers, or FLIR displays while in a moving vehicle, to quick scanning of reconnaissance imagery in ground based photointerpreter facilities. Other potential applications include allowing the use of space-saving devices available only in small formats, such as liquid crystal video displays. Advantages include absence of facial contact, no diopter adjustment necessary, operator may wear glasses incorporating astigmatic corrections, and wide angle viewing (45-deg field of view) to allow correct perspective presentation. The lack of distortion reduces eye fatigue and reduces the likelihood of nausea while viewing in an unstable environment. Distortion inherent in certain image intensifier tubes can be partially corrected with a biocular viewer. Author

**A86-19581**

### KA-102 FILM/EO STANDOFF SYSTEM

R. T. TURPIN (Itek Corp., Optical Systems Div., Lexington, MA) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 31-41.

An assessment is made of the design features and performance capabilities of the KA-102 airborne reconnaissance camera, which possesses a film-or-electrooptic (EO) selection feature and is coupled to a real time data link. The EO focal plane is a continuous line array of 10,240 CCD elements operating in the 'pushbroom' mode. EO imagery can be transmitted up to 500 nm at 75 Mbit/sec. At the ground station, the imagery is calibrated and displayed in real time on three CRTs; image enhancement and magnification for detailed study may be undertaken, as well. O.C.

**A86-19583**

### KS-146A CAMERA DEVELOPMENT AND FLIGHT TEST RESULTS

T. AUGUSTYN (Recon/Optical, Inc., Barrington, IL) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 50-55.

In 1979, there began the development of the KS-146 A 1676-mm focal length, f/5.6 frame camera system designed exclusively for long range oblique photographic missions. The goal was to produce a stabilized system tailored for use with relatively slow, but high-definition films such as EK 3412 and 3414, while also providing growth potential to an electro-optical (E-O) real-time sensor. A detailed design description of the system was presented in 1981. Since then, six systems have been fabricated, evaluated and flight tested over a wide range of airborne conditions. All systems are now operational and the results obtained have confirmed that all objectives have been achieved. Airborne resolution of 8.5 microrad has consistently been demonstrated at slant ranges exceeding 30 n mi. Modular construction, and the flexibility inherent in the KS-146A design, makes the conversion to an E-O sensor straightforward, and the effort to expand the capabilities of the system have begun. Details of the camera development and a review of flight test results are presented. The modification to convert the system to near real time are also discussed. Author

**A86-19585**

### A NEW GENERATION ADVANCED I.R. LINESCAN SENSOR SYSTEM

D. B. DUKE, G. B. MCQUEEN, and P. V. ADAMS (British Aerospace, PLC, Dynamics Group, Hatfield, England) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 61-70.

One of an advanced generation of infrared Linescan Sensors with superior performance, small size, and low weight is described. These systems provide horizon to horizon across-track coverage which, coupled with electronic roll stabilization, provides a far greater probability of target detection than earlier systems. The optics, detector, cooling system, and electronics of the sensor are described, as are the three Line Replaceable Units in the system. C.D

**A86-19586**

### EVOLUTION OF REAL TIME AIRBORNE RECONNAISSANCE

W. J. UTTLEY-MOORE, R. CAREW-JONES, T. MORGAN, P. J. WILLIAMS, and R. C. RANKIN (Computing Devices Co., St. Leonards-on-Sea, England) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 71-78.

An outline of the requirements for a modern reconnaissance system as fitted to a tactical strike aircraft is presented. Film based reconnaissance systtems, as used in many existing installations, are discussed with emphasis on their failure to meet many of the requirements. Systems providing aircrew with immediate access to sensor data are discussed. Particular emphasis is given to the Panavia Tornado RMS 3000 system utilizing video tape and cockpit imagery. A basic ground station whihc could be used with the RMS 3000 system is discussed, stressing the wide range of facilities provided. The paper concludes with some future possibilities for this type of system. Author

**A86-19587**

### COMPUTER CONTROLLED OPERATION OF RECONNAISSANCE CAMERAS

R. LYON, A. BIENER, and F. PALAZZO (Fairchild Weston Systems, Inc., Syosset, NY) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 79-81.

Reconnaissance cameras are now controlled by real-time computer/microprocessor systems. The processor may control the camera stabilization and scanning, autofocus, exposure control and data annotation functions. Operator interface may be minimal with a simple control panel or quite extensive with sophisticated display/keypad subsystems. Target selection may be controlled by an operator or the camera may be automatically driven by the processor system using a predetermined mission profile updated by aircraft flight data. Author

**A86-19588**

### AUTOMATIC EXPOSURE CONTROL EMPLOYING SCENE STATISTICS IN RECONNAISSANCE CAMERAS

R. LYON (Fairchild Weston Systems, Inc., Syosset, NY) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 82-84.

A method is described for modifying the exposure value in aerial reconnaissance using an automatic process which discriminates against nonrelevant information. A microprocessor is used to determine the best exposure value based on scene statistics. Brightness data are obtained from a 'look-ahead' CCD sensor, and scene statistics are computed and processed using an exposure control algorithm. The use of the hardware employed in this method is described. C.D.

**A86-19591**

### CAMERA FLIGHT TESTS AND IMAGE EVALUATION

U. J. V. RINGH (Forsvaret Materielverk, Linkoping, Sweden) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 94-100. refs

This paper describes camera flight tests and image evaluation for conventional cameras as they are carried out by the Swedish Defense Material Administration (FMV). The image evaluation method used is resolving power by use of three bar target. A special square target (4 x 4 m) is also used to measure contrast ratio on the film with a microdensitometer. Results of contrast measurements are given from tests carried out in good weather conditions with a horizontal visibility of more than 30 km. The measured contrast ratios and theoretical predicted values have been compared. The model used for this prediction of atmospheric contrast reduction is compiled from known literature. The comparison shows that the model used for the prediction was usable. Author

**A86-19597**

### SENSOR CONTROL AND FILM ANNOTATION FOR LONG RANGE, STANDOFF RECONNAISSANCE

T. G. SCHMIDT, O. L. PETERS, and L. H. POST (McDonnell Douglas Electronics Co., St. Charles, MO) IN: Airborne reconnaissance VIII; Proceedings of the Meeting, San Diego, CA, August 21, 22, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 134-141.

This paper describes a Reconnaissance Data Annotation System that incorporates off-the-shelf technology and system designs providing a high degree of adaptability and interoperability to satisfy future reconnaissance data requirements. The history of data annotation for reconnaissance is reviewed in order to provide the base from which future developments can be assessed and technical risks minimized. The system described will accommodate new developments in recording heat assemblies and the incorporation of advanced cameras of both the film and electro-optical type. Use of microprocessor control and digital bus interface form the central design philosophy. For long range, high altitude, standoff missions, the Data Annotation System computes the projected latitude and longitude of central target position from aircraft position and attitude. This complements the use of longer ranges and high altitudes for reconnaissance missions. Author

**A86-19617**

### AIR TARGETING OF THE THIRD KIND - AIRBORNE VEHICLES

J. F. GILMORE (Georgia Institute of Technology, Atlanta) IN: Applications of digital image processing VII; Proceedings of the Meeting, San Diego, CA, August 21-24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 330-340. refs

The majority of research in the area of image analysis over the last several years has centered on ground-based object and region analysis. Recent events have stirred an interest in the detection and classification of aircraft in flight. This paper surveys the six algorithms which have been successful applied to the problem of aircraft classification. Each algorithm is analyzed in terms of relative strengths and weaknesses. Summary results of the filter operators, aircraft types, evaluation imagery, problems addressed, and algorithm assumptions are presented for each approach considered. Author

**A86-19620**

### TOWARDS ROBUST IMAGE MATCHING ALGORITHMS

T. J. PARSONS (British Aerospace, PLC, Dynamics Group, Hatfield, England) IN: Applications of digital image processing VII: Proceedings of the Meeting, San Diego, CA, August 21-24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 436-444. refs

An effort to develop a robust image matching system suitable for use in an automatic image matching navigation system with a thermal IR sensor is reported. First, the requirements for an image matching algorithm are formulated, and the image data-base used in the study is described. An overview is then presented of a suggested image processing based navigation system, with attention given to preprocessing, processing, feature extraction, and to the Scene Matching by Area Correlation system. It is shown that the best edge maps for a wide variety of images are obtained by looking for edge crossing in a D.O.G. (Difference of Gaussian) convolved image significantly above the noise level. Finally, the use of techniques based on relational graphs in developing a robust image matching algorithm and the concept of the Problem Based Language Extension are briefly reviewed. V.L.

**A86-19636*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### DESCRIPTION OF AND RESULTS FROM CAMERA SYSTEMS FOR RECORDING DAYTIME LIGHTNING STRIKES TO AN AIRPLANE IN FLIGHT

P. W. BROWN (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p.

(AIAA PAPER 84-0020)

Photographic still and movie and video camera systems have been developed to reveal more about the characteristics of daytime lightning strikes to airplanes in flight. Equipment selection and design is particularly important with regard to time of event occurrence, time correlation between cameras, rapidity of actuation, ease of photogrammetric analysis, and selection of fields of view. The most recent such camera systems flown in an NASA F-106B research airplane are described and design considerations are discussed. Daytime depictions of lightning strikes are presented as illustrative of some of these considerations. Author

**A86-19764*#** Systems Control Technology, Inc., Palo Alto, Calif.

### DEVELOPMENT OF A KNOWLEDGE ACQUISITION TOOL FOR AN EXPERT SYSTEM FLIGHT STATUS MONITOR

J. D. DISBROW (Systems Control Technology, Inc., Palo Alto, CA), E. L. DUKE, and V. A. REGENIE (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs

(AIAA PAPER 86-0240)

Two of the main issues in artificial intelligence today are knowledge acquisition and knowledge representation. The Dryden Flight Research Facility of NASA's Ames Research Center is presently involved in the design and implementation of an expert system flight status monitor that will provide expertise and knowledge to aid the flight systems engineer in monitoring today's advanced high-performance aircraft. The flight status monitor can be divided into two sections: the expert system itself and the knowledge acquisition tool. This paper discusses the knowledge acquisition tool, the means it uses to extract knowledge from the domain expert, and how that knowledge is represented for computer use. An actual aircraft system has been codified by this tool with great success. Future real-time use of the expert system has been facilitated by using the knowledge acquisition tool to easily generate a logically consistent and complete knowledge base. Author

**A86-20505**

### A HIGH BANDWIDTH SIGNAL DISTRIBUTION SYSTEM FOR AIRCRAFT STORES MANAGEMENT SYSTEMS (SMS)

F. LUPINETTI, F. INGELS (Mississippi State University, MS), and R. DUNN (USAF, Eglin AFB, FL) IN: SOUTHEASTCON '84; Proceedings of the Conference, Louisville, KY, April 8-11, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 164-168.
(Contract F08635-82-K-0375)

A model is presented of an FDM (frequency division multiplexing) system for high bandwidth video information transfer for military aircraft according to the MIL-STD 1760 requirements. The choice for an active bus system is briefly justified and numerical results obtained with a simulation computer program are used to illustrate the performance of the model. D.H.

**A86-21163#**

### DEVELOPMENT OF AN AIRBORNE CCD SCANNER FOR LAND AND SEA APPLICATIONS

N. J. J. BUNNIK, H. POUWELS, L. AARTMAN, P. BINNENKADE (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), C. SMORENBURG (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Technisch Physische Dienst TNO, Delft, Netherlands) et al. IN: International Symposium on Remote Sensing of Environment, 18th, Paris, France, October 1-5, 1984, Proceedings. Volume 2 . Ann Arbor, MI, Environmental Research Institute of Michigan, 1985, p. 713-721.

An airborne multispectral scanner based on the use of CCD detector arrays has been developed. The device is known as CAESAR (CCD Airborne Experimental Scanner for Applications in Remote sensing). The CAESAR project has mainly the objective to increase Dutch experience with respect to the application of CCD detectors for earth observation, giving particular attention to the exploration of the technical problem areas associated with the use of CCD detectors. A second objective is related to the stimulation of application-oriented research in the use of multispectral data for land and sea observation by means of a versatile system specified by existing user requirements. After the development and test phase, the project will be continued with an application-oriented evaluation phase to be executed in 1985. The present article provides a description of the user specifications, the design of the sensor system, and the onboard data handling system. Attention is given to the first results of flight tests conducted in July 1984. G.R.

**A86-21234#**

### UNITED STATES COAST GUARD ACQUISITION OF REMOTE SENSING CAPABILITY FOR OCEAN SURVEILLANCE

J. R. WHITE (USCG, Washington, DC) IN: International Symposium on Remote Sensing of Environment, 18th, Paris, France, October 1-5, 1984, Proceedings. Volume 3 . Ann Arbor, MI, Environmental Research Institute of Michigan, 1985, p. 1605-1615.

An account is given of the U.S. Coast Guard development of an airborne, real-time, all-weather, day/night remote sensing system that will detect oil slicks at sea and identify violating vessels. The system has been designated 'Aireye' and will be installed on six of the 41 new Falcon 20 G jet aircraft (military designation HU-25A) which the Coast Guard has recently purchased as its medium range surveillance aircraft. The sensor system will include a side-looking airborne radar, three channel IR/UV line scanner, aerial reconnaissance camera, airborne data annotation system, and a control-display-record console. An active gated television camera will be used to identify vessels at night. D.H.

**A86-22386**

### ANALYSIS OF THE F/A-18 HORNET FLIGHT CONTROL COMPUTER FIELD MEAN TIME BETWEEN FAILURE

P. GRIFFIN (General Electric Co., Aerospace Control Systems Dept., Binghamton, NY) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 108-114.

The F/A-18 FCSE (Flight Control System Electronics) is a four channel (quad redundant) digital fly-by-wire system contained in nine Weapon Replaceable Assemblies (WRA's). The system is built by an American aerospace company. The present paper is concerned with the Flight Control Computer (FCC) which is the heart of the quad configuration for the FCSE. Each computer contains dual channels. Included in the conducted analysis are 131 relevant failures for a total of 62,769 aircraft operating hours, or 125,538 FCC operating hours. The field experienced MTBF (Mean Time Between Failure) of 958 is compared against the predicted MTBF of 851. Attention is given to problems arising in connection with reliability predictions, reliability planning and management philosophy, part type failure distribution, reliability prediction based on updated integrated circuit junction temperatures, and the IC environmental duty cycle. G.R.

**N86-16212*#** Bolt, Beranek, and Newman, Inc., Cambridge, Mass.

### FINDS: A FAULT INFERRING NONLINEAR DETECTION SYSTEM PROGRAMMERS MANUAL, VERSION 3.0

R. E. LANCRAFT Dec. 1985 174 p refs
(Contract NAS1-16579)
(NASA-CR-177986; NAS 1.26:177986; REPT-6012) Avail: NTIS HC A08/MF A01 CSCL 01D

Detailed software documentation of the digital computer program FINDS (Fault Inferring Nonlinear Detection System) Version 3.0 is provided. FINDS is a highly modular and extensible computer program designed to monitor and detect sensor failures, while at the same time providing reliable state estimates. In this version of the program the FINDS methodology is used to detect, isolate, and compensate for failures in simulated avionics sensors used by the Advanced Transport Operating Systems (ATOPS) Transport System Research Vehicle (TSRV) in a Microwave Landing System (MLS) environment. It is intended that this report serve as a programmers guide to aid in the maintenance, modification, and revision of the FINDS software. Author

**N86-16214#** Army Test and Evaluation Command, Aberdeen Proving Ground, Md.

### STRESS LEVEL TESTING OF ELECTRONICS, AVIONICS COMMUNICATIONS AND C3I EQUIPMENTS Final Report

30 Aug. 1985 28 p
(AD-A159395; TOP-6-1-002) Avail: NTIS HC A03/MF A01 CSCL 17B

This Test Operations Procedure (TOP) describes test methods and techniques for measuring and evaluating the technical performance of a System Under Test (SUT) when the SUT is operated to and beyond specifications in order to determine its response to high levels of stimuli. The extremely short period allowed for the writing of this TOP along with the great diversity of potential systems to be tested has precluded the writing of a document which conclusively covers the topic of stress level testing. This document should be considered as a TOP which outlines the basic requirements and the basic test methodology for conducting stress level testing. This TOP includes only the electronics aspect of stress level testing. It does not consider the classical environmental and mechanical stress testing of materials; these types of stress testing are covered in MIL-STD-810D. GRA

**N86-16215#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**DESIGN AND EVALUATION OF AN INSTRUMENTATION SYSTEM FOR MEASUREMENTS IN NONSTEADY SYMMETRICAL FLIGHT CONDITIONS WITH THE HAWKER HUNTER MK 7**

K. VANWOERKOM 1984 83 p refs

(VTH-LR-308) Avail: NTIS HC A05/MF A01

A flight test instrumentation system with a sample of rate 400 measurements/sec, and 0.02% overall accuracy is described. The system was used to perform nonsteady symmetric flight tests with a Hawker Hunter aircraft. The design and evaluation of transducers, signal conditioning, and the data collection system are outlined. The program demonstrates the technique of measuring performance characteristics as well as stability and control characteristics simultaneously in dynamic flight conditions. Author (ESA)

**N86-17351*#** Illinois Univ., Urbana-Champaign. Computer Systems Group.

**ERROR PROPAGATION IN A DIGITAL AVIONIC PROCESSOR: A SIMULATION-BASED STUDY**

D. LOMELINO and R. K. IYER 1986 39 p refs

(Contract NAG1-613)

(NASA-CR-176501; NAS 1.26:176501) Avail: NTIS HC A03/MF A01 CSCL 01D

An experimental analysis to study error propagation from the gate to the chip level is described. The target system is the CPU in the Bendix BDX-930, an avionic miniprocessor. Error activity data for the study was collected via a gate-level simulation. A family of distributions to characterize the error propagation, both within the chip and at the pins, was then generated. Based on these distributions, measures of error propagation and severity were defined. The analysis quantifies the dependency of the measured error propagation on the location of the fault and the type of instruction/microinstruction executed. Author

**N86-17352#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**THE APPLICATION OF SENSORS IN LIGHT TESTS**

S. S. VANLEEUWEN 16 May 1984 12 p refs Presented at 2nd S and A Symposium, Enschede, Netherlands, 1-2 Nov. 1984

(NLR-MP-84056-U; B8568098) Avail: NTIS HC A02/MF A01

Evaluation of transducers used in flight test data collection systems is described. Needs for flight test transducers are discussed. Static laboratory tests, duration tests, environmental tests, and tests in laboratory aircraft are outlined. Pressure, temperature, position, acceleration, vibration, and sound transducers, and gyros are covered. Author (ESA)

**N86-17353#** Kollsman System-Technik G.m.b.H., Munich (West Germany).

**DEVELOPMENT OF A PIEZOELECTRIC QUARTZ PRESSURE SENSOR FOR AVIONICS WITH EXCELLENT LONG TERM STABILITY (WITH FINAL DEMONSTRATION OF THE RESULTS ON A PROTOTYPE) Final Report, Nov. 1984**

M. R. RISCH Bonn, West Germany Bundesministerium fuer Forschung und Technologie Aug. 1985 72 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie, Bonn, West Germany

(BMFT-FB-W-85-010; ISSN-0170-1339) Avail: NTIS HC A04/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 15

An accurate, stable pressure sensor was developed for avionics using quartz as a pressure-sensitive element, a copper-beryllium beam balance for pressure transfer, calculators for digitization, and two identical high frequency piezoelectric surface wave resonators for improved accuracy. Sensor pressure and temperature dependence were tested. Pressure sensitivity changes with temperature, at 0.05% per C. As errors are 0.1% for hysteresis, repeatibility, temperature hysteresis, and long term drift, the pressure sensor can be mass produced. Nonlinearity and temperature dependence are 1% but can be compensated with a microprocessor. Author (ESA)

**N86-17354#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**RELIABILITY ASPECTS OF SOFTWARE FOR DIGITAL AVIONICS**

G. J. DEKKER 1985 95 p refs Revised

(Contract RB-RLB-1982-1-3.3)

(NLR-TR-82126-U; B8568394) Avail: NTIS HC A05/MF A01

Methods to develop reliable software based avionics systems, especially for safety critical functions, are reviewed. The differences between analog and digital systems, and the policy of the FAA to certify software based systems are presented. Methods to minimize the number of errors during software development, methods to remove as many errors as possible via testing, and methods to minimize the effect of remaining errors during operational flights are outlined. A safety analysis regarding common-mode failures is given. Reliability related techniques used by avionics manufacturers are discussed. Author (ESA)

## 07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-19677*#** Purdue Univ., West Lafayette, Ind.

**AN EXPERIMENTAL INVESTIGATION OF PROPELLER WAKES USING A LASER DOPPLER VELOCIMETER**

R. M. SUNDAR (Embry-Riddle Aeronautical University, Prescott, AZ) and J. P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.

(Contract NSG-3135)

(AIAA PAPER 86-0080)

The results of experimental investigations on three single rotation propellers are summarized in this paper. Force measurements showed a definite improvement in efficiency at low advance ratios and in static operation due to use of proplets. Extensive velocity measurements were made using a LDV system. The large amounts of data gathered are presented to reveal clearly the tip vortex streaming back from the propeller. The velocities were also processed using momentum theorem to obtain the thrust and power radial distributions as well as the integrated thrust and power coefficients. The thrust coefficient compared well with force measurements and theoretical prediction from vortex lattice and Goldstein analysis. However, the power coefficient calculated from the momentum analysis was consistently lower than the theoretical or measured values. The measured velocities were also used to compute the vorticity and the trajectory of the tip vortex in the wake behind the propeller. Author

**A86-19678*#** Flow Research, Inc., Kent, Wash.

**PROPELLER DESIGN BY OPTIMIZATION**

M. H. RIZK and W.-H. JOU (Flow Industries, Inc., Kent, WA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs

(Contract NAS3-24533)

(AIAA PAPER 86-0081)

The feasibility of designing propellers by an optimization procedure is investigated. A scheme, which solves the full potential flow equation about a propeller by line relaxation, is modified so that the iterative solutions of the flow equation and the design parameters are updated simultaneously. Some technical problems in using optimization for designing propellers with maximum efficiency are identified. Approaches for overcoming these problems are presented. Author

**A86-19853#**

**SMALL SCALE WIND TUNNEL TESTING OF MODEL PROPELLERS**

R. M. BASS (Dowty Rotol, Ltd., Gloucester, England) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs

(AIAA PAPER 86-0392)

The difficulty and cost of measuring the performance of full scale propellers can be avoided by the use of models operating at correct Mach numbers. Inevitably the Reynolds numbers are low and it is a matter of great difficulty to scale model behavior to full size. In order to obtain a better understanding of scale effects a series of experiments has been conducted in a variable density tunnel in which the separate effects of Reynolds number and Mach number were studied and conclusions drawn as to the limit of validity of model tests. In addition to the obvious effects of Reynolds and Mach number, other effects present are being investigated. To explore the pressure distribution over the blades, a rig has been constructed in which blade surface pressure on a rotating model can be measured. The rig is described and the salient features of data reduction discussed. Some results indicating the potential of the rig are presented. Author

**A86-19888#**

**INFRARED EMISSION FROM JET ENGINE EXHAUST PLUMES**

H. F. NELSON (Missouri-Rolla, University, Rolla) and E. O. TUCKER AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. Research supported by McDonnell Douglas Astronautics Co. refs

(AIAA PAPER 86-0465)

B2O3 particle IR scattering and emission property data concerning scattering cross sections, albedo, and scattering phase functions, which were generated on the basis of radiative reflection and transmission data from the literature, are subjected to a Kramers-Kronig analysis in order to convert radiative data into index-of-refraction values. Scattering parameters required by the Standardized IR Radiation Model (SIRRM) code are obtained from the refractive index values using Mie scattering analysis for 2-25 micron wavelength radiation. SIRRM is used to calculate the broadside IR radiation emitted from isothermal and homogeneous models of turbojet and ramjet exhaust plumes, and it is found that radiant emission increases with increasing particle size and particle mass loading. O.C.

**A86-19895*#** Stanford Univ., Calif.

**ANALYSIS OF INTERACTING DUAL LIFTING EJECTOR SYSTEMS**

T. S. LUND, D. A. TAVELLA, and L. ROBERTS (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs

(Contract NCC2-150)

(AIAA PAPER 86-0478)

An analytical treatment is presented for a flowfield generated by a pair of interacting, two-dimensional parallel jets, representative of the two exhaust streams issuing from the thrust augmentor nozzles of dual lifting jet VTOL aircraft propulsion systems. Predictions of the analysis for the ratio of primary to secondary velocity are in close agreement with experimentally observed values, if the spreading rate parameter is allowed to assume a value greater than that which applies to a free jet. Theoretical results are combined with existing experimental data for unventilated jets, in order to arrive at an estimate of the thrust augmentation produced by a jet pair with an arbitrary degree of ventilation. O.C.

**A86-19965#**

**AN ANALYTICAL INVESTIGATION OF THE EFFECTS OF SWIRLER DESIGN ON THE PERFORMANCE OF ANNULAR PROPULSIVE NOZZLES**

J. D. HOFFMAN, H. D. THOMPSON, and D. L. MARCUM (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. USAF-sponsored research. refs

(AIAA PAPER 86-0587)

An analytical performance prediction methodology for annular propulsive nozzles with swirl introduced in the combustor upstream of the nozzle is presented. The methodology is applied to investigate the effects of swirler design on the performance of annular propulsive nozzles. Four types of swirlers were investigated: free vortex, constant angle, forced vortex, and Rankine vortex swirlers. Discharge coefficients, specific impulses, and wall pressure distributions are presented. These numerical studies show that the discharge coefficient, the thrust, and the vacuum specific impulse decrease as the amount of swirl increases, but that the decrease in specific impulse is modest. The effect of swirl on the discharge coefficient, for all four swirler designs, correlates well with the mass-averaged swirl introduced into the flowfield by the swirler. However, the decrease in vacuum specific impulse is a function of the swirler design. The forced vortex swirler has the least decrease in specific impulse with increasing swirl while the free vortex swirler has the greatest decrease. This methodology will enable nozzle designers to account for the effects of swirl in nozzle design. Author

**A86-20233*#** Massachusetts Inst. of Tech., Cambridge.

**LINEAR-QUADRATIC GAUSSIAN WITH LOOP-TRANSFER RECOVERY METHODOLOGY FOR THE F-100 ENGINE**

M. ATHANS, P. KAPASOURIS, E. KAPPOS, and H. A. SPANG, III (MIT, Cambridge, MA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 434-444) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 45-52. Research supported by General Electric Corp. Previously cited in issue 21, p. 2997, Accession no. A84-43450. refs

(Contract NAG2-297; NGL-22-009-124)

**A86-20369*#** Texas A&M Univ., College Station.

**A NUMERICAL METHOD FOR THE DESIGN AND ANALYSIS OF COUNTER-ROTATING PROPELLERS**

S. C. PLAYLE, K. D. KORKAN, and E. VON LAVANTE (Texas A & M University, College Station) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Jan.-Feb. 1986, p. 57-63. refs

(Contract NAG3-354)

(AIAA PAPER 84-1205)

A numerical method has been developed using the techniques of Lock and Theodorsen as described by Davidson to design and analyze counter-rotating propellers. The design method develops the optimum propeller geometry by calculating the planform and twist distribution for each propeller disk through the use of specific inputs of engine shaft horsepower, diameter, and disk spacing. The analysis method calculates the performance of a given counter-rotating propeller system at any flight condition. Using the NACA four-digit airfoil family, the performance of a counter-rotating propeller design for a given flight condition was investigated in the design and analysis mode. Author

**A86-20371**

**VARIABLE CYCLIC TURBOSHAFT TECHNOLOGY FOR ROTORCRAFT OF THE '90S**

C. ROGO and E. H. BENSTEIN (Teledyne CAE, Toledo, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Jan.-Feb. 1986, p. 73-80. Army-sponsored research. Previously cited in issue 18, p. 2622, Accession no. A85-39695. refs

**A86-20448#**

**DISPERSION PROCESS OF JET ENGINE EXHAUST PLUME. II - BUOYANT JET**

A. NISHI (Miyazaki University, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, Oct. 1985, p. 2360-2364.

In the previous paper the initial dispersion process of jet engine exhaust plume was discussed with the data of jet engine field test as well as those of the model test. The momentum dominant region in the jet was treated mainly, and the model test was carried out for a few nozzle heights over the ground board corresponded to the engine installing heights of the aircraft. There are considerable differences in the ratio of inertia to buoyant forces in the jet between the engine operating modes, i.e., in takeoff mode (TO) the inertia is dominant, while the buoyancy is dominant in idling mode (ID). These typical conditions of TO and ID modes were examined and the results are compared with each other and with those of field test. The source position of atmospheric turbulent diffusion after the jet dispersion is estimated from these results. Author

**A86-21896#**

**'SMART' ENGINE COMPONENTS - A MICRO IN EVERY BLADE?**

A. H. EPSTEIN (MIT, Cambridge, MA) Aerospace America (ISSN 0740-722X), vol. 24, Jan. 1986, p. 60-62, 64.

'Smart' gas turbine engine technology applies feedback control to the adaptive variation of component settings in changing local conditions; as in any closed loop control system, the smart engine employs sensors, processors, and actuators. Near-term applications of these principles encompass active control of blade tip clearances and active exhaust nozzle position improvement. Longer-term applications extend to active compressor inlet distortion control, active stall alleviation of compressor flow, and active noise control. Hot section smart features may be very long term design concerns, focusing on turbine blade stress or temperature distribution. O.C.

**A86-22018#**

**FUEL PROPERTY EFFECTS UPON EXHAUST SMOKE AND THE WEAK EXTINCTION CHARACTERISTICS OF THE PRATT AND WHITNEY PT6A-65 ENGINE**

P. SAMPATH, M. GRATTON (Pratt and Whitney Canada, Mississauga), D. KRETSCHMER, and J. ODGERS (Universite Laval, Quebec, Canada) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. Research supported by the Department of National Defence, Department of Regional Industrial Expansion, Pratt and Whitney Canada, and USAF. refs

(ASME PAPER 85-GT-27)

The present paper is concerned with tests involving the use of 10 different fuels in a gas generator. These tests formed part of an investigation of the performance characteristics of small gas turbine combustors, taking into account broadened specification and alternate source fuels. Attention is given to combustor and test equipment, the measurement of exhaust carbon, smoke number relationships, the soot dependence upon air-fuel ratio data, the effect of hydrogen content upon exhaust soot, predictions for the considered engine, carbon formation as a function of engine conditions, and weak extinction characteristics. A correlation parameter which is capable of predicting the effects of different fuels upon the smoke number of several gas turbine engines is presented along with a parameter for predicting weak extinction characteristics. G.R.

**A86-22024#**

**DESIGN OF COMBUSTOR COOLING SLOTS FOR HIGH FILM EFFECTIVENESS. I - FILM GENERAL DEVELOPMENT**

G. J. STURGESS (United Technologies Corp., Engineering Div., East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. refs

(ASME PAPER 85-GT-35)

It is pointed out that in the main combustion chamber of the gas turbine engine the metal liners forming the combustor have to be provided with some form of thermal protection from the high temperatures of the reacting mixture contained therein. An established technique involves injection of a coolant along the outer surface of the component. This approach is referred to as film cooling. For aircraft gas turbines the protective medium is air, although relatively thin thermal barrier coatings are now a frequent additional feature. The devices for introducing cooling air along the liner surface are called slots. In the present paper heuristic arguments are used to derive a dimensionless grouping of internal geometric parameters which describe the lateral or circumferential uniformity of the films produced by practical slots. Experimental data from a number of different practical slot designs are examined in terms of this geometric mixing parameter. It is shown that the film effectiveness depends on this parameter over a wide range of axial distances and film blowing ratios. G.R.

**A86-22025#**

**DESIGN OF COMBUSTOR COOLING SLOTS FOR HIGH FILM EFFECTIVENESS. II - FILM INITIAL REGION**

G. J. STURGESS and G. D. PFEIFER (United Technologies Corp., Engineering Div., East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 9 p. refs

(ASME PAPER 85-GT-36)

A heuristically based geometric grouping has been used to relate the geometry of practical film cooling slots of gas turbine engine combustors to the circumferential uniformity of axial velocity in the film and the average film effectiveness. To be satisfactory, the cooling performance of a slot has been shown to require a low value of this group. A study of film development has been extended to the initial region of the film where cooling performance is at its maximum. It is demonstrated that such a region exists for both practical slots and idealized two-dimensional slots, but that the character of the initial region flow is completely different for practical slots and cannot be described by the same methods as can be used for two-dimensional slots. Author

**A86-22028#**

**THE EFFECT OF FUEL COMPOSITION UPON COMBUSTION PERFORMANCE IN A ROLLS ROYCE TYNE COMBUSTOR**

T. T. BOWDEN and J. H. PEARSON (Shell Research, Ltd., Thornton Research Centre, Chester, England) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. Research supported by the Ministry of Defence of England. refs

(ASME PAPER 85-GT-39)

The combustion performance of a wide range of fuel types has been examined utilizing a single combustor from a Tyne gas-turbine engine. The results provide further evidence to suggest that fuel total hydrogen content provides a better indication of fuel combustion performance than does aromatic content. However, an even better prediction of fuel combustion performance is given by smoke point, although the acknowledged imprecision of the smoke point test does militate against its use as a primary specification requirement. Analysis of certain fuels by (C-13) nuclear magnetic resonance and low resolution mass spectroscopy demonstrates that it is those fuels with high concentrations of polycyclic aromatic whose combustion performance, in terms of flame radiation and exhaust emissions, is underpredicted by fuel total hydrogen content. There are indications that low concentrations of high molecular weight polycyclic aromatics may substantially impair combustion performance. Author

**A86-22029#**

**COLD FLOW AND COMBUSTION EXPERIMENTS WITH A NEW BURNER AIR DISTRIBUTION CONCEPT**

B. J. JOHNSON (United Technologies Research Center, East Hartford, CT), S. J. MARKOWSKI, and H. M. CRAIG (United Technologies Corp., Pratt and Whitney Div., East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX. Mar. 18-21, 1985. 6 p. refs
(ASME PAPER 85-GT-40)

Experiments were conducted with a JT8D-engine sized can combustor modified such that all the combustion and dilution air entered through the burner front face from a single plenum through counter-rotating annular swirlers. Cold flow experiments were conducted to visualize and to develop a mixing and recirculation flow pattern within the combustor which contained annular and central recirculation cells and featured rapid mixing in the downstream section of the combustor. Laser velocimeter measurements, downstream of the air inlet configuration used in the combustion experiments, showed the largest velocity gradients in the tangential velocity profile. Low-pressure combustion experiments were conducted with three flat spray fuel nozzle orientations and three air inlet geometries to determine the general air inlet and fuel injection characteristics required to produce acceptable combustion characteristics with the selected swirler configuration. The combustion experiments included emission, total pressure and total temperature measurements at the burner exit plane. Low emission levels and temperature pattern factors with relatively low burner pressure losses were demonstrated. Author

**A86-22049#**

**DYNAMIC ANALYSIS OF COMPLEX COMPOSITE ROTOR SYSTEMS WITH SUBSTRUCTURE TRANSFER MATRIX METHOD**

L. YAN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 9 p.
(ASME PAPER 85-GT-74)

A substructure transfer matrix method for the dynamic analysis of multi-rotor systems and complex composite systems is presented. When calculating, the rotor system should be decomposed into several single rotor shafts (substructures). Corresponding unknown external loads and deflections are applied to the separated surfaces, rigid support sections and ball joint sections respectively to replace the original connections. According to the connective and boundary conditions of the whole rotor system, a system of equations is established, from which the frequency equation results. The calculating formulas of vibration modes and of unbalanced responses will be easily formed by linear combination method. All computations are performed with the transfer matrix method. This method is intelligible, readily programmed and much simpler than the current transfer matrix method and modal synthesis method. Author

**A86-22074#**

**POWER DENSE GAS TURBINE APUS**

C. RODGERS (Solar Turbines Inc., Turbomach Div., San Diego, CA) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 11 p. refs
(ASME PAPER 85-GT-124)

Meeting the design requirements of smaller size, lower weight, and fast stars over wider operator envelopes for next-generation auxiliary power units (APUs) may conflict with equally compelling requirements for high thermal efficiency, since optimum cycle conditions differ for maximum specific power and lowest specific fuel consumption. Attention is presently given to the design disciplines constraining power density values for small gas turbine-type APUs; centrifugal compressors with integral radial-inflow turbines are highlighted in research efforts. O.C.

**A86-22075#**

**AN IMPROVED SIMPLE METHOD FOR DESIGNING OPTIMUM ANNULAR DIFFUSERS**

R. CAI, H. JIANG, and Y. ZHU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 8 p. Research supported by the Chinese Academy of Sciences. refs
(ASME PAPER 85-GT-126)

A set of simple BASIC codes for calculating the design parameters for axial, radial, and mixed-type annular diffusers is described. The codes are a numerical version of the Mean Stream Line method developed by Wu et al. (1952) for analyzing the two-dimensional flow field in annular diffusers. The main input data for the codes are inlet geometry, the flow parameters of the diffuser, the specific heat ratio of the working fluid, and the Laval number. The codes can be run on a pocket computer within a few minutes. Some sample calculations for an axial diffuser between a gas generator and a power turbine are presented. I.H.

**A86-22081*#** General Electric Co., Cincinnati, Ohio.

**EVALUATION OF FUEL PREPARATION SYSTEMS FOR LEAN PREMIXING-PREVAPORIZING COMBUSTORS**

W. J. DODDS and E. E. EKSTEDT (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 5 p. refs
(Contract NAS3-22006)
(ASME PAPER 85-GT-137)

A series of experiments was carried out in order to produce design data for a premixing prevaporizing fuel-air mixture preparation system for aircraft gas turbine engine combustors. The fuel-air mixture uniformity of four different system design concepts was evaluated over a range of conditions representing the cruise operation of a modern commercial turbofan engine. Operating conditions including pressure, temperature, fuel-to-air ratio, and velocity, exhibited no clear effect on mixture uniformity of systems using pressure-atomizing fuel nozzles and large-scale mixing devices. However, the performance of systems using atomizing fuel nozzles and large-scale mixing devices was found to be sensitive to operating conditions. Variations in system design variables were also evaluated and correlated. Mixing uniformity was found to improve with system length, pressure drop, and the number of fuel injection points per unit area. A premixing system capable of providing mixing uniformity to within 15 percent over a typical range of cruise operating conditions is demonstrated. I.H.

**A86-22091#**

**RE-ENGINING THE HARRIER**

J. D. CYRUS (U.S. Navy, Naval Air Development Center, Warminster, PA) and W. M. VOWLES (Rolls Royce, Ltd., Bristol, England) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 8 p.
(ASME PAPER 85-GT-175)

During the last twenty-eight years the capabilities of the Harrier have improved markedly, due in large measure to advances in the Pegasus propulsion system. New engine models and component improvements with their increased performance and/or weight reductions have produced increased range and payload capability for the aircraft. Because the Harrier is likely to continue in use well into the next century, an engine-aircraft-mission study has been conducted to identify the potential benefits arising from replacing the existing Pegasus engine with an advanced technology engine. These studies have shown that thrust increases associated with increased technology can improve mission capability substantially; radius can be increased by as much as 50 percent on a mission with a vertical takeoff requirement. However, as takeoff constraints are relaxed, aircraft restraints limit the benefits of the advanced technology engines. Author

**A86-22092#**
**T56 DERIVATIVE ENGINE IN THE IMPROVED E-2C**
T. P. LAUGHLIN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and J. TOTH (Grumman Aerospace Corp., Bethpage, NY) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 9 p.
(ASME PAPER 85-GT-176)

Airborne Early Warming for the Navy fleets has been provided for the past 20 years by the E-2 Airframe/T56 engine combination. Although avionic capability has been continually updated to meet the increased threat, the airframe and powerplant have seen only minor changes. Projected mission requirements and future avionic system enhancements require payload increases being limited by the power capability of the present T56 powerplant. Of paramount importance in the E-2 carrier deck operation is the single engine rate of climb capability of the aircraft. This paper discusses the logical evolution of a replacement engine for the E-2C, a derivative T56 engine contracted and designated by the Navy as the T56-A-427, to meet the projected single engine takeoff and other mission requirements. The T56-A-427 provides 24 percent power and 13 percent fuel consumption improvements with identical installation interfaces, and substantially improves E-2C performance characteristics across the flight envelope. Furthermore, the paper shows that meeting these stringent performance requirements with a derivative engine results in a low risk development program and an engine with improved maintainability and reliability, which can capitalize on the in-place logistics support base of the T56.
Author

**A86-22101#**
**3-D DESIGN OF TURBINE AIRFOILS**
J. HOURMOUZIADIS and N. HUEBNER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. refs
(ASME PAPER 85-GT-188)

With modern turbines operating at a high level of efficiency, sophisticated design techniques are needed for further improvements. With the aid of computers three-dimensional aspect like end wall contouring and airfoil stacking can be integrated into the design process. The possibilities presented by the latter to control reaction, loading and secondary flow effects are analyzed and compared with experimental results. The implications for the resulting airfoil geometry are shown and limitations are discussed.
Author

**A86-22116#**
**AXIAL FLOW CONTRA-ROTATING TURBINES**
J. F. LOUIS (MIT, Cambridge, MA) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985 . 9 p. refs
(ASME PAPER 85-GT-218)

Two types of contra-rotating stages are considered; the first uses guide vanes and the second is vaneless. The wheels of the first type use bladings which are mirror images of each other and they operate with inlet and outlet swirl. The second type uses dissimilar bladings in each of the two wheels with axial inlet velocity to the first wheel and axial outlet velocity for the second wheel. An analysis of their performance indicates that both types can reach stage loading coefficients comparable or larger than conventional turbines with the same number of wheels. A comparison of the contra-rotating stages with conventional ones indicate a significant stage efficiency advantage of the contra-rotating over the conventional single rotation stages due mainly to the elimination of stationary vanes. The off-design performance indicates that relative wheel speed must be controlled. The attributes of contra-rotating turbines suggest their potential use in high performance aircraft engines, in dynamic space power systems and in low speed industrial gas turbines. Author

**A86-22126#**
**DEVELOPING CONCEPTS IN THE ROTORDYNAMIC ANALYSIS OF AERO GAS TURBINES**
R. A. BELLAMY, C. P. JONSON, and R. GAFFNEY (Rolls-Royce, Ltd., Derby, England) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 10 p. refs
(ASME PAPER 85-GT-230)

Three-dimensional nonaxisymmetric finite element models of complete aircraft gas turbine engines are routinely used as a design tool by manufacturers, in order to evaluate the static and dynamic structural characteristics of novel designs. These design models yield an order of magnitude more information than earlier ones, but do not allow easy use of the former evaluation criteria because of this expanded information's greater complexity. Animation of the graphics representing model structural response has become an essential part of analyses, in order to clarify the information generated.
O.C.

**A86-22136#**
**EVOLUTION OF THE TURBOFAN AIRCRAFT ENGINE**
M. E. SHANK (United Technologies Corp., Engineering Div., West Palm Beach, FL) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Insitute of Aeronautics and Astronautics, 1985, p. 11-1 to 11-10.

The evolution of the aircraft turbofan engine is broadly outlined, starting with the earliest low bypass ratio engine most widely used in both military transport and commercial applications. The development of this engine is shown to have been critically dependent on parallel development of titanium alloys and processing. Continuing development of low bypass ratio turbofan engines for both military fighter and commercial applications is then described, along with the development of high bypass ratio engines for transport/commerical applications. Important materials, processing, and structural/design problems are described as they relate to particular engines. The paper concludes with brief look at the future of the turbofan engine. Author

**A86-22200**
**THE LITTLE TURBINE BUSINESS**
M. HIRST Air International (ISSN 0306-5634), vol. 30, Jan. 1986, p. 22-27.

A development history is presented for small gas turbine, turbofan, and turboprop engines since the 1950s, for the cases of both military and commercial aircraft applications. Attention is given to designs that have exhibited outstanding versatility of application or exceptionally large production runs, or both. Noteworthy engines are the J85 of the F-5 series aircraft, the Marbore II, of which 4000 examples were built, the Astazou turboprop, the PT6 turboprop (whose rating has gone from an initial 500 shp to 1424 shp), and the T63 military turboshaft. Such high performance small gas turbines as those used by cruise missiles are also noted.
O.C.

**A86-22679#**
**LIQUID FUELED SUPERSONIC COMBUSTION RAMJETS - A RESEARCH PERSPECTIVE OF THE PAST, PRESENT AND FUTURE**
P. J. WALTRUP (Johns Hopkins University, Laurel, MD) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 19 p. refs
(Contract N00024-85-C-5301)
(AIAA PAPER 86-0158)

A development history is presented for research efforts in the field of liquid-fueled supersonic combustion ramjets ('scramjets'), with a view to future development trends. Major areas of intensive concern have been the design features of inlets, isolator air ducts, fuel feed/injection systems, supersonic combustor configurations, and exit nozzles. In addition to ambient temperature and cryogenic fuels, slurry fuels have been considered. It is noted that current understanding of the mechanisms governing mixing and combustion processes in supersonic streams that merge to form a free shear layer is very limited.
O.C.

**N86-16222#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
**SPANWISE REDISTRIBUTION OF ENERGY AND LOSS IN AN AXIAL FLOW COMPRESSOR BY WAKE CENTRIFUGATION Final Report, 15 Sep. 1981 - 15 Mar. 1984**
C. W. WHITFIELD and J. S. KEITH May 1985 119 p
(Contract F33615-81-C-2090)
(AD-A159312; R84AEB460; AFWAL-TR-84-2109) Avail: NTIS HC A06/MF A01 CSCL 20D

The objective of this program was to develop and codify a method for predicting the spanwise redistribution of energy and loss associated with rotor/stator wakes in an axial-flow compressor. The mechanisms considered were: (1) spanwise transport of wake fluid due to imbalance of the radial pressure gradient; and (2) accumulation/dilution of wake fluid at the inner and outer casing. The work consisted of developing computer modules that perform the above defined objectives. This report describes mathematical formulas derived for definition of the peak radial and streamwise velocity decrements/increments in a wake at a blade trailing edge and their decay with downstream distance. Comparisons with data show good agreement in most cases. In addition, the thickness, displacement thickness, and momentum thickness of the wake were calculated and used in the prediction of changes in the circumferential average flow solution caused by the migration of wake fluid across streamlines. GRA

**N86-16223#** Rolls-Royce Ltd., Derby (England).
**THE MECHANICAL DESIGN OF GAS TURBINE BLADING IN CAST SUPERALLOYS**
A. G. DODD 27 Feb. 1985 47 p refs
(PNR-90247) Avail: NTIS HC A03/MF A01

The methods used for the mechanical design of hot gas turbine blading are discussed. A rapid mechanical assessment, done before the design proceeds further, is examined. The method gives an outline of the design specifying material choice, rim load on disks, cross sectional areas and mean level of cooling technology. Failure modes are discussed. It is suggested that they can be overcome by choosing a temperature and stress for each radial position. Blades are optimized by varying the required cooling technology or by changing the cross-sectional areas. Author (ESA)

**N86-16224#** Rolls-Royce Ltd., Derby (England). Mechanical Technology Dept.
**AN ANALYSIS OF RIG TEST DISC FAILURES**
G. ASQUITH 23 Jul. 1985 10 p refs
(PNR-90276) Avail: NTIS HC A02/MF A01

Life prediction criteria for hot gas turbine engine disks are examined. Safety is taken as the prime requirement in turbine design. Factors influencing the total life, and the prediction methods available are discussed. Engine size disk testing to cracking and failure is seen as the most reliable. This is equivalent to the mathematical Monte Carlo analysis. The tests also show which variables are most likely to be significant. Author (ESA)

**N86-16225#** Rolls-Royce Ltd., Derby (England).
**CERTIFICATION OF AEROENGINES FITTED WITH FULL AUTHORITY DIGITAL CONTROL**
V. A. FISHER 23 Jul. 1985 24 p Presented at Certification of Aerospace Propulsion Systems Seminar, Bangalore, India, 6-7 Mar. 1985
(PNR-90287) Avail: NTIS HC A02/MF A01

The problem of certifying electronic control systems as part of the aircraft engine is discussed. The certification is divided into verification and validation of the software and the hardware. Hardware testing includes environmental aspects such as temperature, vibration, electromagnetic compatibility, shock, sand and dust. Software by its very nature can only be presented to human perception by means of documentation. Author (ESA)

**N86-16226#** Rolls-Royce Ltd., Derby (England).
**IS THE TRADITIONAL 150 HOUR ENDURANCE TEST OUTDATED?**
R. EBBS 23 Jul. 1985 30 p Presented at Certification of Aerospace Propulsion Systems Seminar, Bangalore, India, 6-7 Mar. 1985
(PNR-90288) Avail: NTIS HC A03/MF A01

Qualification tests necessary for the granting of aircraft engine type approval are discussed. The evolution of the 150 hr test is described. The shortcomings of these tests are analyzed, together with attempts to modify the tests to be more representative. The direction which the formal requirements are likely to take in the future is considered. Author (ESA)

**N86-16227#** European Space Agency, Paris (France).
**HOT CORROSION IN AIRCRAFT ENGINES**
H. J. RETZER-SCHEIBE Feb. 1985 242 p refs Transl. into ENGLISH of "Heissgaskorrosion in Flugtriebwerken" Cologne, West Germany, 1984 Original report in GERMAN previously announced as ESA-92820
(ESA-TT-887; DFVLR-MITT-84-04) Avail: NTIS HC A11/MF A01; original German version available from DFVLR, Cologne DM 67

Hot corrosion behavior of high temperature materials, in particular heat resistant alloys used in aircraft gas turbines is reviewed. Corrosion phenomena of Ni-base and Co-base alloys were examined by burner rig tests, and protective coating systems were studied. It is found that the alloying constituents Cr, Ti, and Y improve the hot corrosion resistance while Fl, Mo, and W deteriorate the sulfurization resistance. Author (ESA)

**N86-17355#** Washington Univ., St. Louis, Mo. School of Engineering and Applied Science.
**EFFECT OF DYNAMIC STALL AND ELASTIC PARAMETERS ON THE FUNDAMENTAL MECHANISMS OF HELICOPTER VIBRATIONS Final Report, 1 Sep. 1983 - 31 Aug. 1985**
D. A. PETERS 1 Sep. 1985 11 p
(Contract DAAG29-83-K-0133)
(AD-A160022; ARO-20538.3-EG) Avail: NTIS HC A02/MF A01 CSCL 20K

This research dealt with the modeling and solution of rotary-wing dynamics. In the modeling area, it deals with elastic-blade models, ways to introduce rotor-body coupling, aerodynamic behavior near blade-tips, and the modeling of dynamic stall. In solution strategies, we have concentrated on new and improved Floquet methods, on innovative trim methodologies (such as auto-pilot and periodic shooting), on efficient formulation of equations, and on lifting-line and lifting-surface meshes. GRA

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-19728*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
**DYNAMICS AND CONTROLS FLIGHT TESTING OF THE X-29A AIRPLANE**
J. GERA (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs
(AIAA PAPER 86-0167)

A brief description of the flight control system of the X-29A forward-swept-wing flight demonstrator is followed by a discussion of the flight test techniques and procedures in the area of flight dynamics and control. These techniques, which evolved during the initial few months of flight testing, are based on integrating flight testing with simulation and analysis on a flight-by-flight basis.

A limited amount of flight test results in dynamic stability and handling qualities is also presented. Author

**A86-19729#**

**USE OF DIFFERENTIAL LEADING EDGE FLAPS FOR LATERAL CONTROL AT HIGH ANGLE OF ATTACK**

D. T. WARD and L. J. STOUT (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. Research sponsored by the General Dynamics Corp. and Texas A & M University. refs

(AIAA PAPER 86-0168)

The use of differential leading-edge flaps (DLEF's) in providing roll control at high angles of attack on a high-performance fighter configuration was investigated by conducting a series of wind tunnel (WT) tests and six-degree-of-freedom simulations. The WT tests, performed on a GD/FW WT model planform, were primarily concerned with determining the roll control effectiveness with outboard ailerons, DLEFs, and trailing-edge flaps (flaperons) compared at angles of attack of 30 to 40 deg. A realistic flight control system model (EASY 4) was combined with the TW test database to generate a computer simulation (CS). The CS was validated by comparison with flight test data for a similar aircraft. The CS time histories showed that, even at a low dynamic pressure of 25 psf, a roll rate of up to 50 deg/s can be developed between 30 and 40 deg angles of attack. At a dynamic pressure of 200 psf, estimated roll rates of about 90 deg/s were generated. I.S.

**A86-19818*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EXPERIMENTAL STUDY OF EFFECTS OF FOREBODY GEOMETRY ON HIGH ANGLE OF ATTACK STATIC AND DYNAMIC STABILITY**

J. M. BRANDON and L. T. NGUYEN (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs

(AIAA PAPER 86-0331)

A series of low speed wind tunnel tests on a generic fighter model with a cylindrical fuselage were made to investigate the effects of forebody shape on static and dynamic lateral/directional stability. Five forebodies, including a chine nose of unconventional cross-sectional shape, were tested. Conventional force tests were conducted to determine static stability characteristics and single degree-of-freedom free-to-roll tests were used to study the wing rock susceptibility of the model with the various forebodies. Flow visualization data were obtained to aid in analysis of the complex flow phenomena involved. The results show that forebody cross-sectional shape can strongly effect both static and dynamic (roll) stability at high angles of attack. Large variations in stability were obtained for the various forebody geometries. These characteristics result from the impact of cross-sectional shape on forebody vortex development, the behavior of the vortices at sideslip conditions, and their interaction with the wing and empennage flow fields. Author

**A86-19819*#** Vigyan Research Associates, Inc., Hampton, Va.

**EXPLORATORY INVESTIGATION OF DEFLECTABLE FOREBODY STRAKES FOR HIGH ANGLE OF ATTACK YAW CONTROL**

D. M. RAO (Vigyan Research Associates, Inc., Hampton, VA) and D. G. MURRI (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p.

(AIAA PAPER 86-0333)

A deflectable strake concept was investigated on a conical forebody to evaluate its yaw control potential at high angles of attack. In exploratory low-speed tunnel tests using a generic delta wing fighter configuration, antisymmetrically deflected strakes provided useful levels of yaw power at angles of attack when the conventional rudder became totally degraded. Symmetrical strakes prevented side force development at high angles of attack, and provided pitch control through symmetrical deflection. The strake performance was sensitive to its circumferential position on the forebody due to varying interaction of strake vortices with the wing and vertical tail. The low Reynolds number results of this study provided a favorable initial validation of the concept, subject to verification in regard to scale effects. Author

**A86-19820*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**A FLIGHTPATH OVERSHOOT FLYING QUALITIES METRIC FOR THE LANDINIG TASK**

D. T. BERRY (NASA, Flight Research Center, Edwards, CA) AIAA, Aerosapce Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p.

(AIAA PAPER 86-0334)

An analysis was conducted of the attitude and flightpath angle response of configurations used in the Total In-Flight Simulator (TIFS) pitch-rate command systems program. The resutls show poor correlation between pilot ratings and attitude response and indicate that attitude was not a major influence in the results. A strong correlation was found to exist, however, between the amount of fightpath angle peak overshoot and the pilot ratings. This correlation is similar to the best correlations that have been obtained in recent closed-loop and time-domain analyses but has the advantage of greatly simplified implementation and interpretation. Author

**A86-19902#**

**USE OF SIMULATION DURING PRELIMINARY DESIGN OF THE V-22 OSPREY**

N. N. BATRA, L. W. DOOLEY (Bell Helicopter Textron, Inc., Fort Worth, TX), T. A. SHEEHAN, and K. W. GOLDSTEIN (Boeing Vertol Co., Philadelphia, PA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 8 p. refs

(AIAA PAPER 86-0491)

This paper describes the use of piloted simulation during preliminary design of the first operational tilt rotor aircraft. The develeopment and validation of a generic tilt rotor simulation program and its application towards development of the control laws, selection of the pilot's control system, and early evaluation of the handling qualities are discussed. Specific simulation tasks designed to exercise the tilt rotor's characteristics under operating conditions are described. The average handling qualities ratings for the simulated tasks from seven pilots show that the basic aircraft, without the AFCS, will meet Level 2 criteria and, when augmented by the AFCS, will meet Level 1 criteria. Author

**A86-19903#**

**INVESTIGATION OF AIRCRAFT DEPARTURE SUSCEPTIBILITY USING A TOTAL-G SIMULATOR**

G. R. RHODESIDE (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs

(AIAA PAPER 86-0492)

An assembly of generic aircraft configurations have been tested for their departure and spin susceptibility and their high angle of attack flying qualities using the Naval Air Development Center's (NADC) Dynamic Flight Simulator (DFS). The DFS produces the total-G environment needed to replicate actual flight. It does this because it harnesses the vector and angular accelerations provided by NADC's three-degree-of-freedom centrifuge. An elegant control algorithm takes pilot inputs and orients and acceleratos the DFS cockpit in such a manner as to yield a high level of flight fidelity. Static lateral-directional stability derivatives and inertias were varied in the experiment so as to examine the departure criteria under question (Cn-beta DYNAMIC and Lateral Control Departure Parameter, LCDP) thus providing information which will be used to develop a design guide or specification. Analysis shows the departure regions defined by Cn-beta DYN and LCDP are a good indication of departure flying qualities in the high angle of attack realm. An updated, more objective departure rating scale has been devised based on considerations of this experiment. Author

**A86-19905#**

**AN ENGINEERING SIMULATION OF THE BOEING 747 PRIMARY FLIGHT CONTROL SYSTEMS**

H. H. STRAUB (Boeing Commercial Airplane Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.

(AIAA PAPER 86-0494)

A high-fidelity force-input simulation of the primary flight control systems of a 747 commercial aircraft is described. The performance characteristics of the major hardware components (pilot and copilot control, cable systems hydraulic actuator, and linkages) were modeled in detail, and minor modifications were incorporated to achieve a satisfactory match to aircraft ground test data. The simulation can be run in real time on an analog computer without integration problems and can be used as an engineering tool for the evaluation of hardware modifications to both the manual and autopilot control paths. The simulated flight control data are given together with ground test results in dynamic and static test conditions. A block diagram describing the simulation approach is provided. I.H.

**A86-20236*#** Minnesota Univ., Minneapolis.

**DESIGN OF AN ACTIVE FLUTTER SUPPRESSION SYSTEM**

B. S. LIEBST, W. L. GARRARD (Minnesota, University, Minneapolis), and W. M. ADAMS (NASA, Langeley Research Center, Hampton, VA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 222-232) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 64-71. Previously cited in issue 21, p. 2998, Accession no. A84-43425. refs

(Contract NAG1-217)

**A86-20237*#** Grumman Aerospace Corp., Bethpage, N.Y.

**CONTROL OF A FORWARD-SWEPT-WING CONFIGURATION DOMINATED BY FLIGHT DYNAMIC/AEROELASTIC INTERACTIONS**

M. RIMER, R. CHIPMAN, and B. MUNIZ (Grumman Aerospace Corp., Bethpage, NY) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 212-221) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 72-79. Previously cited in issue 21, p. 2998, Accession no. A84-43424. refs

(Contract NAS1-17102)

**A86-21318**

**FLIGHT STABILITY AND CONTROLLABILITY. II - AIRCRAFT LONGITUDINAL STABILITY [STABILNOST I UPRAVLJIVOST LETELICA. II - UZDUZNA STABILNOST AVIONA]**

M. NENADOVIC (Beograd, Univerzitet, Belgrade, Yugoslavia) Belgrade, Masinski Fakultet Univerziteta u Beogradu, 1985, 727 p. In Serbo-Croatian. refs

Various aspects of aircraft static and dynamic longitudinal stability and control are covered in this textbook, with the appropriate equations presented. Reference is made to maneuverability and control surface strength criteria for large aircraft, static longitudinal stability in relation to trim and control forces, and the effects of fuselage flexibility on longitudinal stability and control. B.J.

**A86-21840#**

**A REDUNDANT STRAPDOWN REFERENCE FOR ADVANCED AIRCRAFT FLIGHT CONTROL SYSTEMS**

L. CAMBERLEIN and P. NICAISE (Societe d'Applications Generales d'Electricite et de Mecanique, Paris, France) IN: Symposium Gyro Technology 1984; Proceedings of the Symposium, Stuttgart, West Germany, September 11, 12, 1984 . Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1984, p. 15.0-15.27.

This paper shows the advantage of the skewed axis redundancy and of two-axis dry tuned gyros for providing electric flight control systems with a strapdown reference. It describes the theoretical features of the skewed axis redundancy and provides the results of laboratory tests performed on the development system MSDO3. As a conclusion, the article describes a reference, for fighter aircraft flight control systems, that provides, in addition, backup attitude and navigation. Author

**A86-21900#**

**TALKING TO YOUR AIRCRAFT**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, Jan. 1986, p. 84-86, 88.

The most promising development trends and performance capability prospects for cockpit control voice recognition systems are considered, with attention to the solution of the problems of contextuality that inhere in the semantics of spoken languages. The recognition of speech in the high stress and frequently noisy environment of military aircraft cockpits presents especially troublesome design problems. Emphasis is on the recognition of commands for the execution of a given task that may be couched in very different sentences by the same pilot at different times. O.C.

**A86-22309#**

**TERRAIN FOLLOWING AVOIDANCE TECHNIQUE OF VERY LOW ALTITUDE PENETRATION**

Y. ZHENG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Aug. 1985, p. 313-320. In Chinese, with abstract in English. refs

Aircraft guidance in very low altitude penetration, especially the terrain-following technique, is addressed. The development of the latter technique from the early N method to the modern adaptive angle method, as well as the optimal control method now under development, is reviewed. Recent progress in this field, such as terrain storage, combined terrain following, and terrain avoidance technique, among others, is introduced. C.D.

**A86-22317#**

**GUST ALLEVIATION USING COMBINED CONTROL LAWS**

J. CHANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Aug. 1985, p. 379-384. In Chinese, with abstract in English.

An analytical method of gust alleviation and other active control purposes (relaxed static stability, etc.) for an airplane is described. Gust alleviation uses direct measurements of atmospheric turbulence to yield a feed-forward or open-loop control law. It is relatively insensitive to changes in flight conditions. Thus a combined control law can be obtained which contains feed-back and feed-forward components. The stability of the gust alleviation system and the performances of other active control purpose can be satisfied by obtaining a linear optimal control defined by a quadratic performance index. Thus the performance index is combined, and the optimal feed-back control law is straightforward and well-known. An application of the combined control law to a flexible airplane is presented. Calculations have been performed to obtain the normal acceleration responses of the airplane to the turbulence and the state responses for the other active control purpose. Author

**N86-16228*#** Connecticut Univ., Storrs.

**AN INVESTIGATION OF ADAPTIVE CONTROLLERS FOR HELICOPTER VIBRATION AND THE DEVELOPMENT OF A NEW DUAL CONTROLLER Final Report**

P. MOOKERJEE, J. A. MOLUSIS, and Y. BAR-SHALOM Jan. 1985 162 p refs

(Contract NAG2-213)

(NASA-CR-177377; NAS 1.26:177377) Avail: NTIS HC A08/MF A01 CSCL 01C

An investigation of the properties important for the design of stochastic adaptive controllers for the higher harmonic control of helicopter vibration is presented. Three different model types are considered for the transfer relationship between the helicopter higher harmonic control input and the vibration output: (1) nonlinear; (2) linear with slow time varying coefficients; and (3) linear with constant coefficients. The stochastic controller formulations and solutions are presented for a dual, cautious, and deterministic controller for both linear and nonlinear transfer models. Extensive simulations are performed with the various models and controllers. It is shown that the cautious adaptive controller can sometimes result in unacceptable vibration control. A new second order dual controller is developed which is shown to modify the cautious adaptive controller by adding numerator and denominator correction terms to the cautious control algorithm. The new dual controller is simulated on a simple single-control vibration example and is found to achieve excellent vibration reduction and significantly improves upon the cautious controller. Author

**N86-16229#** European Space Agency, Paris (France).
**FLIGHT DYNAMICS AND AIRCRAFT PILOTING**
J. C. WANNER May 1985 419 p refs Transl. into ENGLISH of "Dyn. du Vol et Pilotage des Avions" ONERA-P-1983-1 Paris, France, 1983 Revised
(ESA-TT-874; ONERA-P-1983-1; ONERA-P-1976-6-REV) Avail: NTIS HC A18/MF A01

The principle of piloted vehicle mechanics is presented, and aircraft longitudinal movement is studied. Assuming that the pilot counters with his lateral controls any sideslip, and that the aircraft plane of symmetry is vertical, the trajectory is described in that same vertical plane. The natural modes (angle of attack oscillation, phugoid, aperiodic motion) of the small movements around straight and level flight, the response to the pilots commands, and equilibrium stability, are examined. Small lateral movements around straight and level flight and the aircraft response to lateral controls are considered. Small movements of the aircraft around stabilized level flight in rotation are also examined. The assumptions of separation of longitudinal and lateral movements around stabilized straight and level flight are validated. Author (ESA)

**N86-17357** Engineering Sciences Data Unit, London (England).
**ESTIMATION OF SIDEFORCE, YAWING MOMENT AND ROLLING MOMENT DERIVATIVES DUE TO RATE OF YAW FOR COMPLETE AIRCRAFT AT SUBSONIC SPEEDS**
Apr. 1984 52 p refs Submitted for publication
(ESDU-84002; ISBN-0-85679-463-5; ISSN-0141-397X) Avail: ESDU

ESDU 84002 demonstrates how methods given elsewhere in the Sub-series for estimating the contributions to the derivatives Y sub r, N sub r and L sub r due to individual major parts of the airframe (wing, bodies, flaps and fin) may be combined to provide values for the complete aircraft. The overall accuracy achieved is illustrated by correlation plots showing comparison of prediction with flight test and wind tunnel results drawn from many sources in the literature; for a diverse range of configurations broadly Y sub r is predicted within 0.05, N sub r within 0.025 and L sub r within 0.02. A simplified method for estimating complete aircraft yawing derivative values is also included. Author

**N86-17358*#** Kansas Univ., Lawrence. Flight Research Lab.
**DEVELOPMENT OF A SENSITIVITY ANALYSIS TECHNIQUE FOR MULTILOOP FLIGHT CONTROL SYSTEMS Final Report**
A. H. VAILLARD, J. PADUANO, and D. R. DOWNING Oct. 1985 162 p refs
(Contract NCC2-293)
(NASA-CR-166619; NAS 1.26:166619) Avail: NTIS HC A08/MF A01 CSCL 01C

This report presents the development and application of a sensitivity analysis technique for multiloop flight control systems. This analysis yields very useful information on the sensitivity of the relative-stability criteria of the control system, with variations or uncertainties in the system and controller elements. The sensitivity analysis technique developed is based on the computation of the singular values and singular-value gradients of a feedback-control system. The method is applicable to single-input/single-output as well as multiloop continuous-control systems. Application to sampled-data systems is also explored. The sensitivity analysis technique was applied to a continuous yaw/roll damper stability augmentation system of a typical business jet, and the results show that the analysis is very useful in determining the system elements which have the largest effect on the relative stability of the closed-loop system. As a secondary product of the research reported here, the relative stability criteria based on the concept of singular values were explored. B.W.

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## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-19324**
**THE NEW 'DUAL STAGE' TEST PROCEDURE FOR LOW COST MEASUREMENT OF PARACHUTE PERFORMANCE**
R. W. HUNTER (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 157-160.

The Parachute Service Life Extension Program represents a joint Navy and Air Force program which was initiated in 1983 with the aim to establish scientifically-based service and storage lives for personnel parachutes. The criteria selected for establishing the optimum service and storage lives are related to age-caused changes in parachute reliability and material properties. In order to determine the number of tests (per parachute type) required to statistically measure the effects of aging on reliability, a test plan was prepared. In accordance with this plan, 280 reliability tests were initially scheduled for Fiscal Year 1984. The two standard test procedures considered for the reliability tests are discussed, taking into account certain problems. As a solution to these problems, a dual stage test procedure was developed. This procedure consists of two parts, including a descent rate measurement test and a parachute stress test. G.R.

**A86-19328**
**BALLISTIC GAS FIRED DEVICES**
P. MILCETIC (U.S. Navy, Naval Ordnance Station, Indian Head, MD) and M. SCHIMMEL (McDonnell Aircraft Co., St. Louis, MO) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 179-182. refs

The Naval Ordnance Station has conducted a program researching the feasibility of using hot gases from a standard initiator to ignite an explosive train, with an output which initiates percussion primers. This technique eliminates parts required in standard firing mechanisms, including the firing pin, O-ring seal, and shear pin. This allows redundant primers to be incorporated into an existing single primer firing mechanism without changing the exterior envelope. One hundred and six 'breadboard' tests were conducted over the temperature range of -65 F to +165 F, using various ballistic hose configurations, including simulation of specific aircraft escape systems. The feasibility and reliability of this technique is examined by analyzing the test results. Application of this design to other escape system devices is also discussed in this paper. . Author

**A86-19340**
**DEVELOPMENT OF A GENERALIZED ESCAPE SYSTEM SIMULATION COMPUTER PROGRAM**
L. A. DAULERIO (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) and D. A. FENDER (Ketron, Inc., Warminster, PA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 246-250. refs

It is pointed out that the development of escape systems for safely ejecting crewmembers from high performance military aircraft is a complex and demanding task. For this reason, the U.S. Navy has based research for the improvement of escape systems partly on the mathematical simulation of the operation of such systems. The present paper is concerned with the development of a simulation model which has now become known as the Generalized Escape System. Simulation (GESS) program. The GESS program divides the ejection sequence into three primary phases. The model is based upon the numerical integration of the six degree-of-freedom equations of motion for each of four basic program elements. Development issues are discussed, taking into account coordinate systems and transformations, aerodynamic coefficients, computational considerations, the dynamic center of gravity, the user interface, and aspects of verification. G.R.

**A86-19703#**

**REFLECTIONS REGARDING RECENT ROTARY RIG RESULTS**

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 8 p. refs

(AIAA PAPER 86-0123)

Recent rotary rig experiments are examined to evaluate how well they simulate dynamic conditions existing in full scale flight. It is found that most rig designs used are prone to cause significant interference with the vortex wake shed from an advanced aircraft at high angles of attack. The support interference problem can be aggravated substantially by the coupling existing in the critical Reynolds number range between vehicle motion and boundary layer transition, a coupling that is unlikely to have been simulated in most wind tunnel tests. Author

**A86-19727*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**THE ROLE OF A REAL-TIME FLIGHT SUPPORT FACILITY IN FLIGHT RESEARCH PROGRAMS**

A. L. MOORE (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p.

(AIAA PAPER 86-0166)

This paper presents some of the approaches taken by the NASA Western Aeronautical Test Range (WATR) of Ames Research Center to satisfy the ever-increasing real-time requirements of research projects such as the F-14, F-15, advanced fighter technology integration (AFTI) F-16, YAV-8B, and the X-29A. The approaches include the areas of data acquisition, communications (video and audio), real-time processing and display, data communications, and tracking. Author

**A86-22188**

**FACILITY FOR CLOSED LOOP TESTING OF AIRCRAFT CONTROL SYSTEMS**

J. BLAETZ (McDonnell Aircraft Co., St. Louis, MO) IN: Environmental integration technology today for a quality tomorrow; Proceedings of the Thirtieth Annual Technical Meeting, Orlando, FL, May 1-3, 1984 . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 319-321.

Improvements in aircraft performance have brought the need for more precise testing of flight control systems prior to flight. McDonnell Aircraft Company has developed a flight control system functional mockup for the AV-8B Harrier II to perform tests on the completely integrated aircraft flight control system. A high-speed digital computer incorporated into the functional mockup permits testing of the flight control system in real time. The computer, employing parallel processors, solves the non-linear equations of motion that describe the aircraft's six degrees of freedom. This paper describes the computer system, its programming, and the interfacing of the computer with the functional mockup. The paper also discusses the functional mockup design, instrumentation, and data collection and analysis. Typical test operations on the flight control systems are also described. Author

**A86-22189**

**PERFORMANCE OF AV-8B HARRIER II STRUCTURAL TEST PROGRAM**

J. V. MURPHY, D. E. SCHNORING, and H. C. TOURKAKIS (McDonnell Aircraft Co., St. Louis, MO) IN: Environmental integration technology today for a quality tomorrow; Proceedings of the Thirtieth Annual Technical Meeting, Orlando, FL, May 1-3, 1984 . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 322-327.

As part of the AV-8B Harrier II Full-Scale Development Program, a structural test program, including both static and fatigue tests, was conducted from 1981 through 1983. The program was satisfactorily completed, within cost and on schedule, which attests to the high efficiency of the structure. The static tests related to the flight placards were completed ahead of schedule, as desired, and the two-lifetime fatigue test was also completed early. This paper describes how the combined efforts of NAVAIR and MCAIR led to the accomplishment of the program objectives. It also illustrates that the success of the program was a function of advance planning, effective communications, in-depth status monitoring, and maintaining basic program objectives. Author

**A86-22687*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SIMULATION AND ANALYSIS OF NATURAL RAIN IN A WIND TUNNEL VIA DIGITAL IMAGE PROCESSING TECHNIQUES**

K. M. AARON, M. HERNAN, P. PARIKH, V. SAROHIA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and M. GHARIB (California, University, La Jolla) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 6 p. refs

(Contract NAS7-918; NASA ORDER RE-65-459; NASA TASK 505-45-00-04-59)

(AIAA PAPER 86-0291)

It is desired to simulate natural rain in a wind tunnel in order to investigate its influence on the aerodynamic characteristics of aircraft. Rain simulation nozzles have been developed and tested at JPL. Pulsed laser sheet illumination is used to photograph the droplets in the moving airstream. Digital image processing techniques are applied to these photographs for calculation of rain statistics to evaluate the performance of the nozzles. It is found that fixed hypodermic type nozzles inject too much water to simulate natural rain conditions. A modification uses two aerodynamic spinners to flex a tube in a pseudo-random fashion to distribute the water over a larger area. Author

**N86-16230** Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.

**SIMULATION OF A SIX DEGREES OF FREEDOM FLIGHT SIMULATOR MOTION SYSTEM**

G. J. WIERDA 1 May 1982 47 p refs

(UA-00-39) Avail: Issuing Activity

A model of a single hydraulic actuator and controller developed to investigate nonlinearities in the servo valve transfer function to limit the amount of hardware in the simulation, was simplified by linearizing the square roots in the pressure-flow relationship. Six of the simplified models were coupled to obtain a simulation model of a complete six degrees of freedom motion system. A transformation and mass matrix to describe the dynamic equations were calculated for a motion system. Simulation results indicate high underdamped frequency components in the acceleration response of the actuators. It is shown that acceleration feedback rather than force feedback is preferred to damp the high frequency components. Author (ESA)

**N86-16232*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**STUDY OF ICE ACCRETION ON ICING WIND TUNNEL COMPONENTS**

J. E. NEWTON and W. OLSEN 1986 24 p refs Presented at the 24th Aerospace Sciences Meeting, Reno, Nev., 6-8 Jan. 1986; sponsored by AIAA

(NASA-TM-87095; E-3828; NAS 1.15:87095) Avail: NTIS HC A02/MF A01 CSCL 01E

In a closed loop icing wind tunnel the icing cloud is simulated by introducing tiny water droplets through an array of nozzles upstream of the test section. This cloud will form ice on all tunnel components (e.g., turning vanes, inlet guide vanes, fan blades, and the heat exchanger) as the cloud flows around the tunnel. These components must have the capacity to handle their icing loads without causing significant tunnel performance degradation during the course of an evening's run. To aid in the design of these components for the proposed Altitude Wind Tunnel (AWT) at NASA Lewis Research Center the existing Icing Research Tunnel (IRT) is used to measure icing characteristics of the IRT's components. The results from the IRT are scaled to the AWT to account for the AWT's larger components and higher velocities. The results show that from 90 to 45 percent of the total spray cloud froze out on the heat exchanger. Furthermore, the first set of turning vanes downstream of the test section, the FOD screen and the fan blades show significant ice formation. The scaling shows that the same results would occur in the AWT. Author

**N86-16233*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PROGRESS IN THE LEWIS RESEARCH CENTER ALTITUDE WIND TUNNEL (AWT) MODELING PROGRAM**

C. C. CIEPLUCH, R. R. BURLEY, D. E. GROESBECK, and J. C. MAREK 1986 19 p refs Proposed for presentation at the 14th Aerodynamic Testing Conference, West Palm Beach, Fla., 5-7 Mar. 1986; sponsored by AIAA

(NASA-TM-87194; E-2850; NAS 1.15:87194) Avail: NTIS HC A02/MF A01 CSCL 14B

The rehabilitation of the Altitude Wind Tunnel (AWT) at the NASA Lewis Research Center is under study with the goal of providing a modern subsonic wind tunnel for conducting propulsion system/airframe integration, isolated propulsion system, propulsion acoustics and adverse weather tests. Because of the increased Mach number capability (from Mach 0.6 to 0.9 plus) and the incorporation of acoustic and adverse weather capabilities into an existing tunnel, the AWT rehabilitation represents a significant technical challenge. In order to reduce the risk associated with such an undertaking, and extensive AWT modeling program is being conducted to guide and verify the tunnel design. Significant findings and progress in this modeling program are the subject of this paper. Author

**N86-16235#** Duits-Nederlandse Windtunnel, North East Polder (Netherlands).

**GERMAN-DUTCH WIND TUNNEL (DNW). PRESENT AND FUTURE APPLICATIONS FOR INDUSTRIAL DEVELOPMENTS [DEUTSCH-NIEDERLAENDISCHER WINDKANAL (DNW). GEGENWAERTIGER UND KUENFTIGER EINSATZ FUER INDUSTRIELLE ENTWICKLUNGEN]**

J. BARCHE 1983 43 p refs In GERMAN Presented at 3rd BMFT Statusseminar Luftfahrtforschung und Luftfahrttechnology, Hamburg, West Germany, 2-4 May 1983

Avail: NTIS HC A03/MF A01

The German-Dutch wind tunnel was designed to perform aerodynamic and aeroacoustic development investigations in the subsonic range. The wind tunnel is composed of closed test sections with transverse sections of 6 m x 6 m, 8 m x 6 m and 9.5 m x 9.5 m and with respective velocity of 150, 120, and 60 m/sec, and of open test sections with 8 m x 6 m entry surface and with a maximum velocity of 80 m/sec. The tunnel is applied for productive testing of aircraft, vehicles and civil engineering, for demonstration, calibration and system integration. Author (ESA)

**N86-16236#** Duits-Nederlandse Windtunnel, North East Polder (Netherlands).

**AEROACOUSTIC CALIBRATION OF THE GERMAN-DUTCH WIND TUNNEL (DNW) OPEN JET**

R. ROSS (National Aerospace Lab., Northeast Polder, Netherlands), J. W. G. VANNUNEN (National Aerospace Lab., Northeast Polder, Netherlands), K. J. YOUNG (Boeing Commercial Airplane Co., Seattle, Wash.), R. M. ALLEN (Boeing Commercial Airplane Co., Seattle, Wash.), and J. C. A. VANDITSHUIZEN 1983 102 p refs

(DNW-TR-82-03; D6-51501) Avail: NTIS HC A06/MF A01

The aerodynamic and acoustic quality of the German-Dutch Wind Tunnel open jet test section configuration was established. The flow quality is found to be excellent; for the core region angular deviations up to 0.1 deg, turbulence levels of 0.2% and dynamic pressure deviations of 0.5% are reported. Near the shear layer these values become higher. The anechoic quality meets reasonably high standards. The acoustic correction procedures for 1/3 octave analysis were checked. The usual shear layer correction has to be extended to correct for turbulence effects for high tunnel velocity, high frequency, and the most forward and the most rearward propagation angles from the sound source. This correction is independent of the position of the model in the flow and the type of sound source (tone or broadband). Author (ESA)

**N86-16237#** Duits-Nederlandse Windtunnel, North East Polder (Netherlands).

**ACOUSTIC EVALUATION OF THE GERMAN-DUTCH WIND TUNNEL (DNW) SHEAR LAYER CORRECTION USING A MODEL JET**

W. H. HERKES (Boeing Commercial Airplane Co., Seattle, Wash.), F. G. STROUT (Boeing Commercial Airplane Co., Seattle, Wash.), R. ROSS (National Aerospace Lab., Northeast Polder, Netherlands), and J. C. A. VANDITSHUIZEN 1983 140 p refs

(DNW-TR-82-04; D6-51502) Avail: NTIS HC A07/MF A01

Acoustic tests of a 6-cm model jet were conducted in the German-Dutch Wind Tunnel 6m by 8m free jet facility to evaluate a free jet shear layer correction procedure that adds an empirical correction to the previous theoretical correction. Static-flight effects on jet noise measured in the flow were used to evaluate the corresponding out-of-flow results. The experiment demonstrates that the procedure significantly improves the accuracy of the flight effects measured by the out-of-flow microphones. Comparisons of the out-of-flow free jet results to results obtained in closed wind tunnels and from aircraft flyovers show consistent trends. Author (ESA)

**N86-16238#** Duits-Nederlandse Windtunnel, North East Polder (Netherlands).

**AERODYNAMICAL CALIBRATION OF THE GERMAN-DUTCH WIND TUNNEL (DNW): A REVIEW OF TESTING TECHNIQUES AND RESULTS**

Feb. 1983 7 p

(DNW-PA-82062) Avail: NTIS HC A02/MF A01

System checkout, performance measurement, and aerodynamical calibration of the German-Dutch Wind Tunnel are summarized. Mechanical and electrical system tests; flow quality measurements; static and dynamic performance assessment; temperature and pressure distribution measurement; and turbulence and spectral characteristics measurement are described. Author (ESA)

# 10

# ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-20244#**

**A PARALLEL QUASI-LINEARIZATION ALGORITHM FOR AIR VEHICLE TRAJECTORY OPTIMIZATION**

P. K. A. MENON and L. L. LEHMAN (Integrated Systems, Inc., Palo Alto, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 119-121. Previously cited in issue 07, p. 862, Accession no. A85-19792. refs
(Contract F08635-83-C-0480)
(AIAA PAPER 85-0498)

**N86-16243*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SUPERSONIC AERODYNAMIC CHARACTERISTICS OF SOME REENTRY CONCEPTS FOR ANGLES OF ATTACK TO 90 DEG**

M. L. SPEARMAN Nov. 1985 32 p refs
(NASA-TM-87645; NAS 1.15:87645) Avail: NTIS HC A03/MF A01 CSCL 22B

Past studies of reentry vehicles tested to high angles of attack (up to 90 deg) in the Mach number range from 2 to 4.8 are reviewed. Two basic planforms are considered: highly-swept deltas and circular. The delta concepts include variations in cross section (and thus volume) and in camber distribution. The effectiveness of various types of aerodynamic control devices is also included. The purpose of the paper is to examine the characteristics of the vehicles with a view toward the potential usefulness of such concepts in a flight regime that would include reentry from space into the atmosphere followed by a transition to sustained atmospheric flight. Author

# 11

# CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-19312**

**A SCIENTIFIC METHOD FOR DETERMINING THE USEFUL LIFE OF EXPLOSIVE DEVICES IN AIRCRAFT**

W. E. EARLY, JR. (General Dynamics Corp., Fort Worth, TX) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 81-88.

Attention is given to an effort by the F-16 System Program Office to determine the useful service life of all explosive devices encompassed by an aircraft crew escape system. This entailed both the experimental determination of the true thermal environment of these explosive devices under worst case operational conditions, and the performance of accelerated service life tests for groups of each type of device to ascertain the safe life of each under the measured conditions. O.C.

**A86-19313**

**THE USE OF TLX ENERGY TRANSFER LINES ON THE F-16 AIRCRAFT**

W. E. EARLY, JR. (General Dynamics Corp., Fort Worth, TX) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 89-94.

This paper describes TLX (Thin Layer Explosive) in the form in which it has been developed for use on the F-16 aircaft and traces its evolution from the original Swedish product. It illustrates the current applications of TLX in the F-16 and gives the reasons why it has superseded two other types of linear-explosive lines. It summarizes the design requirements established by General Dynamics and the recently completed qualification test program. It discusses some of the advantages of this new product over older types of linear-explosive products (SMDC, FCDC, etc.). In addition, it briefly describes significant informal tests performed to evaluate the safety and ruggedness of TLX. Author

**A86-19349*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**APPROACH FOR SERVICE LIFE EXTENSION OF EXPLOSIVE DEVICES FOR AIRCRAFT ESCAPE SYSTEMS**

L. J. BEMENT (NASA, Langley Research Center, Hampton, VA) and M. L. SCHIMMEL (McDonnell Aircraft Co., St. Louis, MO) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 334-341.

Service life extension of explosive devices used in aircraft escape systems can achieve considerable savings. An overall approach is needed to challenge the logic of explosive component service extension from design to removal from service for evaluation. The purpose of the effort described in this paper was to develop a service-extension approach on explosive devices used in aircraft systems, supported by actual testing of representative candidate devices, to evaluate quantitatively the effects of service, age, and degradation, and allow responsible, conservative service life determinations. Evaluated were five explosive components: rigid and flexible explosive transfer lines, one-way transfers, flexible linear shaped charges, and initiation handles. The service extension approach generated in this effort is summarized by eight recommendations. Author

**A86-19929*#** United Technologies Research Center, East Hartford, Conn.

**LONG TERM DEPOSIT FORMATION IN AVIATION TURBINE FUEL AT ELEVATED TEMPERATURE**

A. J. GIOVANETTI and E. J. SZETELA (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p.
(Contract NAS3-24091)
(AIAA PAPER 86-0525)

An experimental characterization is conducted for the relationships between deposit mass, operating time, and temperature, in coking associated with aviation fuels under conditions simulating those typical of turbine engine fuel systems. Jet A and Suntech A fuels were tested in stainless steel tubing heated to 420-750 K, over test durations of between 3 and 730 hr and at fuel velocities of 0.07-1.3 m/sec. Deposit rates are noted to be a strong function of tube temperature; for a given set of test conditions, deposition rates for Suntech A exceed those of Jet A by a factor of 10. Deposition rates increased markedly with test duration for both fuels. The heated tube data obtained are used to develop a global chemical kinetic model for fuel oxidation and carbon deposition. O.C.

**A86-20037#**

### RESEARCH ON HIGH-STRENGTH AEROSPACE ALUMINUM ALLOYS

J. T. STALEY (Aluminum Company of America, Alloy Technology Div., Pittsburgh, PA) (CASI, Annual General Meeting, 31st, Ottawa, Canada, May 28, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, March 1985, p. 14-29. refs

The utilization of aluminum alloys in airframe designs is discussed. The present aim in aircraft design is to save weight by decreasing density and increasing strength while maintaining corrosion resistance and increasing toughness, modulus, and fatigue resistance. Aluminum-lithium alloys and wrought powder metallurgy alloys are currently being studied for aircraft structures. Wrought powder metallurgy alloys have 30 percent higher strength than conventional alloys with improved toughness and corrosion. The application of dispersion hardened alloys for temperatures in the range 350-600 F and wrought powder metallurgy alloys for aircraft wheels is described. The fabrication and fatigue testing of the wrought powder metallurgy alloys are analyzed. The development of cost effective, lightweight, and resistant aircraft structures from metal matrix composites, aramid aluminum laminates, and superplastic 7475 is being investigated. I.F.

**A86-20579**

### HIGH STRENGTH NICKEL-PALLADIUM-CHROMIUM BRAZING ALLOYS

D. BOSE, A. RABINKIN, N. J. DE CRISTOFARO (Allied Corp., Metglas Products, Parsippany, NY), and A. DATTA (EG&G Sealol, Inc., Providence, RI) Welding Journal, Research Supplement (ISSN 0043-2296), vol. 65, Jan. 1986, p. 23-s to 29-s. refs

Nickel-palladium based filler metals are investigated as possible replacements for gold-filled filler metals, such as BAu-4, used as brazing alloys for joining aircraft engine components. Like BAu-4, the brazing temperatures of the Ni-Pd alloys are below 1010 C, making them suitable for joining critical aircraft engine components made with gamma-prime hardened superalloys, such as Inconel 718. Elevated temperature mechanical properties, corrosion behavior, and microstructural characteristics of Inconel-718 joints brazed with Ni-Pd compositions and with BAu-4 alloy are found to be comparable. V.L.

**A86-20636**

### DELAMINATION THRESHOLD AND LOADING EFFECT IN FIBER GLASS EPOXY COMPOSITE

C. BATHIAS and A. LAKSIMI (Compiegne, Universite de Technologie, France) IN: Delamination and debonding of materials . Philadelphia, PA, American Society for Testing and Materials, 1985, p. 217-237. refs

Helicopter rotor heads made of glass fiber-epoxy composite show good strength, particularly in fatigue failures. However, interlaminar defects may always grow under the effect of loading in bending. To predict the development of these plane defects, the delamination threshold and low crack growth rate were studied in double cantilever beam-type specimens calibrated by compliance. Experimentally, a delamination threshold exists below which a plane crack does not propagate, either in Mode I or Mode II testing. Fatigue loading may cause the growth of delamination between adjacent plies at a strain energy release rate Delta G(th) five times lower than the fracture energy G(c). This difference is relatively insignificant by comparison with metals, since in numerous alloys the difference can be as high as 100. This demonstrates the importance of determining a delamination threshold to evaluate the damage tolerance of the composite. Complex loadings were introduced into our tests by programming temporary overloads and sequences of loading at two stress levels during cycling. The glass fiber-epoxy composites do not show significant memory effect, but are sensitive to the load ratio R. Author

**A86-21296**

### RECENT DEVELOPMENTS IN CARBON FIBRE COMPOSITE

J. MATSUI, T. NORITA (Toray Industries, Inc., Tokyo, Japan), and M. HIRATA (Soficar, Paris, France) SAMPE Journal (ISSN 0091-1062), vol. 21, Nov.-Dec. 1985, p. 39-44. refs

To fulfill requirements of carbon fiber composite for aircraft structures, intermediate modulus (295 GPa) and higher strength (5600 MPa) carbon fiber TORAYCA T800 was developed. T800 composite shows greatly improved composite properties dominated by fiber such as tensile modulus, compressive modulus, tensile strength without hole and with hole, and through-penetration impact load. There is no effect on transverse tensile strength, compressive strengths, and shear strength with increase of fiber properties. Status of matrix resin developments is also discussed in terms of improvements in transverse cracking and compressive strength after impact. Author

**A86-21701**

### NATIONAL SAMPE TECHNICAL CONFERENCE, 17TH, KIAMESHA LAKE, NY, OCTOBER 22-24, 1985, PROCEEDINGS

Conference sponsored by the Society for the Advancement of Material and Process Engineering. Covina, CA, Society for the Advancement of Material and Process Engineering (National SAMPE Technical Conference Series. Volume 17), 1985, 736 p. For individual items see A86-21702 to A86-21758.

Among the topics discussed are: optically transparent silicon elastomers; bismaleimides; and the ablation characteristics of graphite/epoxy. Consideration is also given to the effects of thermal exposure on the structural and mechanical integrity of graphite fibers; processable polyimide matrix resins; biomedical electronics applications of materials characterization and analysis systems; and P/M titanium shape technology using the ceramic mold process. Additional topics discussed include: microstructure modification of Ti-6Al-4V casings; titanium castings for airframe applications; and heat treatment and forming considerations in processing aluminum-lithium alloys. I.H.

**A86-21707**

### CAST ALUMINUM FATIGUE PROPERTY/MICROSTRUCTURE RELATIONSHIPS

P. C. INGUANTI (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 61-72.

The relationship between the tensile properties, fatigue properties, and the microstructure are examined for two cast aluminum alloys, A201.0 and A357.0, processed by three different foundry techniques. It is shown that A201.O-T7 has consistently high tensile properties but its fatigue strength is low due to casting flaw sensitivity. The fatigue properties of the alloy, however, can be substantially improved through foundry or post-foundry techniques eliminating shrinkage porosity. A357.O-T6 castings, which are free of large shrinkage voids, are found to have the optimum combination of tensile and fatigue properties for application to fatigue loaded components. V.L.

**A86-21710**

### OPTICALLY TRANSPARENT SILICONE ELASTOMERS

M. D. BAILE (Dow Corning Corp., Midland, MI) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 97-105. Research supported by Dow Corning Corp.

A wet process hydrophobic (WPH) silica technology is employed to prepare optically transparent silicone elastomers which embrace a unique combination of property profile. These elastomers can be cured via peroxides or hydrosilation method, in less than 30 minutes at 100 C. The unvulcanized rubber mixture can be processed easily due to its non-tacky surface and low plasticity. A wide range of mechanical properties is obtained: 25-80 Durometer, 500-1100 percent Elongation, 8.3-12.7 MPa Tensile Strength, lap shear adhesion greater than 300 psi to glass,

polycarbonate and acrylic. The optical properties are greater than 90 percent Transmission and less than 22 percent Haze for a 1.27 mm thick elastomer. The shelf life of catalyzed unvulcanized rubber mixture is seven weeks at ambient temperature and greater than seven months at 0 C. These types of elastomers can potentially satisfy important needs in the marketplace such as aircraft windshield interlayer application, thermal adsorber boiler or/photovoltaic cells, medical grade blood pump devices, catheters, elasto-optic transducers, etc.
Author

**A86-21719**

### APPLICATIONS OF TUBULAR COMPOSITE STRUCTURES

D. P. MAASS (Advanced Composite Products, Inc., East Haven, CT) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 200-208.

This paper is intended to portray the broad range of applications for tubular composite parts. These applications are organized by means of structural function (i.e. compression columns, beams, internal pressure vessels, etc.) with specific examples in each case. The parts described, cover a broad range of designs including diameters from .125-arcmin to 16-arcmin, wall thickness from .010-in. to 1-in., materials including glass, Kevlar, oriented polyethylene, and all forms of graphite fiber, solid and sandwich wall construction, etc. The tradeoffs between the various methods for fabricating composite tubes (roll wrapped prepreg, filament winding, pultrusion, braiding, etc.) are also addressed.
Author

**A86-21722**

### IMPACT OF COMPOSITE MATERIALS ON ADVANCED FIGHTERS

M. M. RATWANI (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancoment of Material and Process Engineering, 1985, p. 232-241.

The impact of composite materials on the performance, durability and life cycle costs of advanced fighter aircraft is presented in this paper. The advantages of using high strain fibers, high toughness resin and hybrids in the structural design of advanced composites are discussed. The role of stitching in retarding delamination growth in composites is shown. A brief discussion of composition repairs for combat readiness is also given.
Author

**A86-21726**

### TITANIUM NEAR NET SHAPE COMPONENTS FOR DEMANDING AIRFRAME APPLICATIONS

R. H. WITT and A. L. FERRERI (Grumman Aerospace Corp., Bethpage, NY) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 296-305. refs

This paper deals with the viability of Hot Isostatic Pressing (HIP) Near Net Shape (NNS) titanium parts in competition with forged or cast components. The paper summarizes NNS and advanced alloy capability and experience for each process, and includes economic assessments for specific parts varying in size and complexity. Overall results show that HIP offers greatest near-term potential for producing the complex parts considered in this study.
Author

**A86-21729**

### EFFECT OF MANUFACTURING DEFECTS AND SERVICE-INDUCED DAMAGE ON THE STRENGTH OF AIRCRAFT COMPOSITE STRUCTURES

R. A. GARRETT (McDonnell Aircraft Co., St. Louis, MO) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 325-341. refs

The effects of several types of manufacturing defects and two types of service-induced damage on the static and fatigue strength of aircraft composite structures are examined. The manufacturing defects discussed here include out-of-round holes, delaminations, porosity, improper fastener seating depth, tilted countersinks, interference fit, and multiple installation and removal cycles; the two types of service-induced damage are low energy impact damage and penetration damage. With reference to test results for carbon/epoxy panel structures, it is shown that the above manufacturing defects can be easily detected with correct nondestructive inspection techniques and that the tolerances and controls used in the fabrication and assembly of composite aircraft structures are adequate to assure uniform strength and structural performance. Techniques for reducing the low energy impact and penetration damage are suggested.
V.L.

**A86-21734**

### COMPOSITE FABRICS IN A THERMAL PROTECTION APPLICATION

W. P. DOWNEY, JR. (Fairchild Burns Co., Winston-Salem, NC) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 386-399.

Increased airline passenger cabin fire hardness and increased opportunity for passenger survivability in fire scenarios are objectives of a portion of an on-going FAA regulatory program. The overall program is briefly reviewed. Fire blocking of polyurethane seat cushions with sewn slipcover liners of composite fabrics is taking place now. The stated objective of fire blocking is to provide additional cabin egress time in the event of a post crash fire. Previous small scale cabin material flammability tests are reviewed and compared to the new large scale upholstery system test required to demonstrate fire blocking capability. The performance of a fire blocking fabric is not a stand alone parameter but is greatly influenced by the specific polyurethane foam being protected and the decorative upholstery covering installed over the assembly and these factors are reviewed. Additional selection criteria, other than thermal properties, are also reviewed. The range of currently available fabrics is outlined. Many of the fabrics are of fibers such as Kevlar, nomex, glass, PBI, and carbon, most familiar in structural applications.
Author

**A86-21735**

### ELECTRODEPOSITED PRIMER SCALE-UP AND QUALIFICATION

G. T. BECKWITH and T. POLLARD (Northrop Corp., Hawthorne, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 400-409. USAF-sponsored research.

Northrop has successfully scaled up an electrodeposited, adhesive bonding primer from a three-gallon research cell to a 250-gallon pilot production tank. This primer is a modified-epoxy, water-based material that was developed jointly by Northrop and Sherwin-Williams for use with 82 C (180 F)-service adhesives. Following the successful scale-up, the primer was fully qualified to the MMM-A-132A, MIL-A-25463B, and Fairchild S-F501 adhesive bonding specifications. In the qualification, specimens were fabricated with Dexter-Hysol EA-9628 adhesive on aluminum adherends that were primed cathodically at low voltage (40 to 45 volts). Two production lots of electrodeposited primer were prepared by Sherwin-Williams and evaluated at Northrop. Control specimens were also prepared with BR-127 and EA-9268 adhesive.

Excellent results were obtained with values that were 40 percent to 160 percent above the specification requirements. Author

**A86-21736**

### IMPROVED TEMPERATURE RESISTANT SEALANTS FOR COMPOSITE & ADHESIVE BONDED FUEL-TANK STRUCTURES

E. M. BROWN, A. F. SHARABY, and T. M. CLARK (Products Research and Chemical Corp., Glendale, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 420-427.

More stringent requirements for aircraft sealants have taxed existing materials both from an increased temperature and overall performance need. More recent manufacturing processes require the use of heat for adhesive bonding, and curing composites. In addition, aircraft performance has increased the requirements for sealant stability at higher operating temperatures. The result has been a new family of aerospace sealants that accommodate these demands. These sealants show a two fold retention of physical properties over existing materials. They are compatible with elevated temperature cure cycles and immediate exposure to heat. They may also be used in elevated temperature applications in faying surfaces. The characteristics of these sealants are presented in this paper. Author

**A86-21737**

### FUEL RESISTANT COATINGS FOR APPLICATIONS IN INTEGRAL TANKS & BLADDER FUEL CELLS

E. M. BROWN and S. RANDAZZO (Products Research and Chemical Corp., Glendale, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 428-432.

With the advent of new materials and processes in the aerospace industry, a number of coating applications for fuel containment have been identified. Several new coatings based on Permapol P-3, a unique fuel resistant polymer, show promise in these aircraft applications. These materials provide a variety of chemical structures, physical characteristics and are summarized in this presentation. Author

**A86-21741**

### ADVANCES IN P/M TITANIUM SHAPE TECHNOLOGY USING THE CERAMIC MOLD PROCESS

V. K. CHANDHOK, J. H. MOLL, C. F. YOLTON, and G. R. MCINDOE (Colt Industries, Crucible Research Center, Pittsburgh, PA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 495-506. refs

A study was conducted to improve and define the dimensional control of titanium alloy turbine engine rotors produced using prealloyed powder, the ceramic mold process, and hot-isostatic-pressing. Room temperature and elevated temperature properties are presented and compared to conventional forgings and castings. The results show that P/M process is capable of producing rotors with the combined near-net shape capability of castings and the high mechanical property capability of forgings. Author

**A86-21742**

### UNIQUE TOOLING AND MANUFACTURING APPROACH FOR LARGE ADVANCED COMPOSITE AIRCRAFT STRUCTURE

J. S. WINEGAR (Fiber Technology Corp., Provo, UT) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 507-511.

This paper presents a review of innovative tooling and manufacturing concepts which can be adapted for use in a number of large composite structures. Using filament winding as the primary source of fiber deposition, the method has been successfully developed in a variety of large aircraft parts such as a 10' diameter cowling made as a solid wall graphite/epoxy structure with honeycomb hat ring frames. A sandwich-wall graphite/epoxy fuselage for a general business airplane has been demonstrated and is ready for production. Current government and commercially sponsored programs suggest that new and innovative tooling and manufacturing methods must be developed to make such structures a reality. Author

**A86-21753**

### CURRENT AND POTENTIAL USAGE OF TITANIUM CASTINGS FOR AIRFRAME APPLICATIONS

R. R. BOYER (Boeing Commercial Airplane Co., Seattle, WA), W. F. SPURR, and J. M. EDWARDS (TiTech International, Inc., Pomona, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 624-634.

Only recently have titanium castings begun to see widespread acceptance of their use for aircraft and missile applications. Due to its relatively high cost, the selection of titanium in general and titanium castings in specific requires analysis of a number of tradeoffs. Titanium castings are unique in that they can possess properties equivalent to wrought titanium yielding advantages over other alloy systems in strength to weight ratio, corrosion resistance and high temperature performance. Proper design can maximize their cost effectiveness by utilizing net shape capability to minimize both machining and fabrication operations. A number of current titanium casting applications illustrate the various criteria upon which their selection as production method of choice is based. Finally, higher strength titanim beta alloys such as Ti-15-3-3-3 and Ti-38-6-44 demonstrate excellent potential for future applications. Author

**A86-21756**

### PM TECHNIQUES FOR MAKING NEAR-NET-SHAPE TITANIUM ALLOY COMPONENTS

H. GREWE, J. HARTWIG, and J. WILLBRAND (Krupp GmbH, Essen, West Germany) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 662-676.

**A86-22020#**

### FLAME TEMPERATURE ESTIMATION OF CONVENTIONAL AND FUTURE JET FUELS

O. L. GULDER (National Research Council of Canada, Div. of Mechanical Engineering, Ottawa) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 5 p. refs
(ASME PAPER 85-GT-31)

An approximate formula is presented by means of which the adiabatic flame temperature of jet fuel-air systems can be calculated as functions of pressure, temperature, equivalence ratio, and hydrogen to carbon atomic ratio of the fuel. The formula has been developed by fitting of the data from a detailed chemical equilibrium code to a functional expression. Comparisons of the results from the proposed formula with the results obtained from a chemical equilibrium code have shown that the average error in estimated temperatures is around 0.4 percent, the maximum error being less than 0.8 percent. This formula provides a very fast and easy means of predicting flame temperatures as compared to thermodynamic equilibrium calculations, and it is also applicable to diesel fuels, gasolines, pure alkanes, and aromatics as well as jet fuels. Author

**A86-22022#**
**THE QUANTIFICATION AND IMPROVEMENT OF THE THERMAL STABILITY OF AVIATION TURBINE FUEL**
J. S. MILLS and D. R. KENDALL (Shell Research, Ltd., Thornton Research Centre, Chester, England) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 6 p. refs
(ASME PAPER 85-GT-33)

The rig performance of aircraft fuels are evaluated. The test rig and experimental procedures for testing eleven fuels in a heat exchanger are described. Fuel performance limits between 125-210 C are obtained; it is observed that an increase in operating temperature results in an increase in operational difficulties for certain fuels. The influence of oxidation of fuel on the fuel's performance is examined. It is concluded that the performance of fuels depends on the initiation of radical oxidation reactions and sulfur content. The effect of metals on the oxidation process and fuel is investigated. The metals catalyze the oxidation reactions resulting in low fuel stability. The doping of fuels with metal deactivating additives to reduce the catalytic effect of metals is studied. The additive is effective in reducing the catalyzation; however, the chelates formed contain some residual catalytic activity. I.F.

**A86-22062#**
**STRAIN ISOLATED CERAMIC COATINGS FOR GAS TURBINE ENGINES**
R. P. TOLOKAN, J. B. BRADY, and G. P. JARRABET (Brunswick Corp., Technetics Div., DeLand, FL) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 6 p. refs
(ASME PAPER 85-GT-96)

Plasma sprayed ceramic coatings are used in gas turbine engines to improve component temperature capability and cooling air efficiency. Strain isolated ceramic coatings offer improved coating life and increased insulating capability. A low modulus fiber metal strain isolator between ceramic and metal backing acts to reduce the stress on the ceramic during thermal cycling. Strain isolated coatings can tolerate greater ceramic thickness and broader operating conditions than nonstrain isolated coatings when subjected to thermal shock. Ceramic coatings are durable only within a narrow range of operating conditions. Coating designs should be based on real operating conditions for success. Thermal shock testing is useful for evaluating ceramic coatings if test and sample design are representative of the intended application. Author

**A86-22706*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**RESEARCH ON ANTIMISTING FUEL FOR SUPPRESSION OF POSTCRASH AIRCRAFT FIRES**
V. SAROHIA, P. PARIKH, A. YAVROUIAN, and E. MATTHYS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 20 p. refs
(Contract NAS7-918; NASA ORDER RE-152-293; DOT-FA03-80-A-00215)
(AIAA PAPER 86-0573)

Recent experimental results in the field of post-crash aircraft fire suppression are reviewed, with emphasis given to antimisting kerosene fuel (AMK). Findings in three major areas of study are presented, including: rheological studies (skin friction, and heat transfer); fuel breakup processes and nozzle spray combustion; and the development of inline blenders for production of AMK at the refueling point. An interpretation of the results of the FAA/NASA Controlled Impact Demonstration of AMK fuel is also presented. It is concluded that AMK is a sound concept and offers several advantages over conventional fuels in any crash scenario involving post-crash fires. I.H.

**N86-16273#** Rolls-Royce Ltd., Derby (England). Non-Metallics Labs.
**THE MATERIAL DEVELOPMENT, COMPONENT MANUFACTURE, AND POST-SERVICE EVALUATION OF RB211-524 COWL DOORS UTILIZING CARBON FIBRE COMPOSITE MATERIALS**
G. A. OWENS 23 Jul. 1985 24 p refs
(PNR-90275) Avail: NTIS HC A02/MF A01

A lightweight engine element including carbon fiber reinforced epoxy composite skin bonded to aluminum alloy honeycombs is described. Material selection, mechanical property data and evaluation of the material's environmental resistance are discussed. Corrosion resistance of the honeycomb construction is considered. The effect of the operating conditions is assessed in 6000 hr tests. No significant structural deterioration is exhibited. Author (ESA)

**N86-16276#** Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
**NONDESTRUCTIVE INSPECTION: AN EFFICIENT INVESTMENT [LE CONTROLE NON DESTRUCTIF: UN INVESTISSEMENT RENTABLE]**
F. ALBUGUES 1985 13 p In FRENCH Presented at 4th Journees des Materiaux Composites, Bordeaux, France, 14-15 May 1985
(SNIAS-852-430-110) Avail: NTIS HC A02/MF A01

Nondestructive methods and their application to composite materials inspection in the aircraft industry are reviewed. The methods include visual control, dimension control, radiography, thermography, ultrasonics, acoustic analysis, holographic interferometry, optical microscopy, optoelectronics, and microanalysis. Author (ESA)

**N86-16277#** Societe Nationale Industrielle Aerospatiale, Paris (France).
**ARENYL: A SOLUBLE MOLD TECHNOLOGY [ARENYL: UNE TECHNOLOGIE DE MANDRIN SOLUBLE]**
F. GOFFENEY 1985 5 p In FRENCH Presented at 4th Journees des Materiaux Composites, Bordeaux, France, 14-15 May 1985
(SNIAS-852-430-111) Avail: NTIS HC A02/MF A01

Application of Arenyl to composite materials molding for the aircraft industry is described. Arenyl is composed of polyvinyl alcohol (PVA) and sand, has good mechanical properties and may be disaggregated by water solution of the PVA. It is concluded that Arenyl offers a good solution to molding problems. Aircraft element examples are given. Author (ESA)

**N86-16279#** Societe Nationale Industrielle Aerospatiale, Suresnes (France).
**THE APPLICATIONS OF COMPOSITE MATERIALS IN THE AERONAUTICAL DOMAIN [LES APPLICATIONS DES COMPOSITES DANS LE DOMAINE AERONAUTIQUE]**
G. HELLARD, G. HILAIRE, and M. TORRES Apr. 1985 34 p In FRENCH
(SNIAS-852-551-103) Avail: NTIS HC A03/MF A01

The physical properties and the applications of composite materials to aircraft construction are described. Kevlar, carbon, and glass fiber properties are compared. Weight reduction and cost reduction are examined. Composite elements used in aircraft are described. Author (ESA)

**N86-16315#** Imperial Coll. of Science and Technology, London (England). Computational Fluid Dynamics Unit.
**THE TWO-FLUID MODEL OF TURBULENT COMBUSTION APPLIED TO AN IDEALISED ONE-DIMENSIONAL, UNSTEADY, CONFINED, PRE-MIXED FLAME**
J. Z. Y. WU Aug. 1984 59 p refs
(PDR/CFDU/IC/21) Avail: NTIS HC A04/MF A01

The two-fluid model of turbulent combustion was applied to a one-dimensional, unsteady, confined, premixed flame with idealized initial and boundary conditions. The results show that steady oscillations may occur after the steady-state flame is disturbed. A systematic, parametric study is performed to establish instability regions. The results indicate a possible mechanism of oscillatory burning in, for example, afterburner systems for aircraft jet engines. Author (ESA)

**N86-16374#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**AGARD CORROSION HANDBOOK. VOLUME 1: CORROSION, CAUSES AND CASE HISTORIES**
W. WALLACE (National Research Council, Ottawa, Canada), D. W. HOEPPNER (Toronto Univ.), and P. V. KANDACHAR (Fokker, Schiphol, Netherlands) Jul. 1985 205 p refs
(AGARD-AG-278-VOL-1; ISBN-92-835-1505-6) Avail: NTIS HC A10/MF A01

A need exists to keep aircraft operators and maintenance personnel aware of the science and technology of corrosion as it applies to aircraft structures. Information is provided on the aircraft operating environment, corrosion theory, common airframe materials and their response to corrosion, the detection of corrosion, and methods employed to control corrosion in aircraft structures and materials. Also given are case histories of the deterioration or failure of components in typical aircraft and the means of detection are detailed and the remedical action taken. Microbiological corrosion is also discussed. The handbook is intended to assist in the early diagnosis of developing corrosion problems and in the selection of appropriate corrective measures. Author

**N86-17485#** Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Lab. Techniques Nouvelles.
**EVALUATION OF THE CIBA-GEIGY R6376 IM6 PREPREG [EVALUATION DU PREIMPREGNE CIBA GEIGY R6376-IM6]**
J. LEVESQUE and F. HENRIOT 21 Jan. 1985 74 p In FRENCH
(Contract STPA-83-96-028)
(DGT-26.649) Avail: NTIS HC A04/MF A01

The R6376-IM6 prepreg tensile and impact properties were compared with other commercially available products used in aircraft manufacturing. The comparisons do not show improvements over the currently used preimpregnated composites. Author (ESA)

**N86-17486#** Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Lab. Techniques Nouvelles.
**STUDY OF COMPOSITE MATERIAL CURING MOLDS [ETUDE D'UN SOMMIER DE CUISSON EN MATERIAUX COMPOSITES]**
S. DELLUS 8 Feb. 1985 22 p In FRENCH
(Contract STPA-83-96-028)
(DGT-26.817) Avail: NTIS HC A02/MF A01

A composite mold to manufacture carbon reinforced expoxy matrix composite elements for the aircraft industry is studied. The working temperature for curing is 175C. The tests were carried out either using preimpregnated composites or manually impregnated composites. The study shows that the molds do not differ significantly from the models, that the deformation is low after several autoclave cycles, and that there are consistent advantages regarding weight and thermal inertia. Author (ESA)

**N86-17493#** Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
**COMPOSITE MATERIALS: A SOURCE OF INNOVATION [LES MATERIAUX COMPOSITES: SOURCE D'INNOVATION]**
A. PHAN 1985 7 p In FRENCH; ENGLISH summary Submitted for publication
(SNIAS-852-430-113) Avail: NTIS HC A02/MF A01

A composite materials design methodology based on the concept of user needs technical specifications is proposed. This results from an equilibrium between user requirements and the technological limitations for manufacturing a specified product. The advantages of such a specification are commented on. Author (ESA)

**N86-17498#** Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
**DESIGN OF NONAXYSYMMETRIC STRUCTURES (TURBOJET ENGINE NACELLE ELEMENT) Thesis [CONCEPTION DE STRUCTURES NON AXISYMETRIQUES (ELEMENTS DE NACELLE DE REACTEUR)]**
J. LAMALLE 1985 59 p refs In FRENCH
(SNIAS-852-430-119) Avail: NTIS HC A04/MF A01

The design of an air inlet covering with an average diameter of 2200 mm and length varying between 330 and 510 mm is discussed. The purpose it to show how an asymmetric element can be manufactured by filament winding, using composite materials. The choice of winding procedure is analyzed and all the manufacturing steps are described. The analytical verification of the behavior under external pressure gives results within the specifications. Author (ESA)

## 12

## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-19375*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**LUBRICATION AND PERFORMANCE OF HIGH-SPEED ROLLING-ELEMENT BEARINGS**
E. V. ZARETSKY, F. T. SCHULLER, and H. H. COE (NASA, Lewis Research Center, Cleveland, OH) Lubrication Engineering (ISSN 0024-7154), vol. 41, Oct. 1985, p. 725-732. Previously announced in STAR as N85-21658. refs

Trends in aircraft engine operating speeds have dictated the need for rolling-element bearings capable of speeds to 3 million DN. A review of high-speed rolling-element bearing state-of-the-art performance and lubrication is presented. Through the use of under-race lubrication and bearing thermal management bearing operation can be obtained to speeds of 3 million DN. Jet lubricated ball bearings are limited to 2.5 million DN for large bore sizes and to 3 million DN for small bore sizes. Current computer programs are able to predict bearing thermal performance. Author

**A86-19970*#** Johns Hopkins Univ., Laurel, Md.
**EVOLUTION AND STATUS OF CFD TECHNIQUES FOR SCRAMJET APPLICATIONS**
M. E. WHITE (Johns Hopkins University, Laurel, MD), J. P. DRUMMOND, and A. KUMAR (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 21 p. refs
(AIAA PAPER 86-0160)

Computational Fluid Dynamics (CFD) methods are presently applied to the design and analysis of scramjet propulsion systems for missiles and aircraft operating at speeds in excess of Mach 5, in forms ranging from simple inviscid codes for parametric studies of inlet geometries to Navier-Stokes codes incorporating chemistry models which address complex scramjet combustion phenomena. Attention is given to the development history of CFD for the hypersonic regime, as well as to scramjet flowfield modeling in inlets, combustors and nozzles, and prospective development trends. O.C.

**A86-20173#**

### FATIGUE LIFE PREDICTION UNDER COMPLEX LOAD USING LOCAL STRAIN APPROACH AND RELATIVE MINER'S RULE

A. LUO (Aviation Industry Department, People's Republic of China) and F. WU (Northwest Polytechnic University, Xian, People's Republic of China) Acta Mechanica Solida Sinica, Sept. 1985, p. 327-337. In Chinese, with abstract in English. refs

Crack formation life predictions for two kinds of central notched specimens using local strain approach and relative Miner's (1945) rule (i.e., relative linear cumulative damage rule) are described and discussed in this paper. Crack formation lives of these two kinds of specimens under Fighter Aircraft Loading Standard for Fatigue Evaluation load spectra are obtained. The calculation results were compared with the fatigue testing results, and it was found that the method using a finite element analysis to predict crack formation lives is better than the modified Neuber's (1961) rule. In addition, the accuracy of predicting fatigue lives is considerably improved when a local strain approach combined with the relative Miner's rule is used, instead of the commonly used Miner's rule. Author

**A86-20175#**

### MEASUREMENT OF ELASTIC-PLASTIC STRAIN FIELD AT THE CURVE SURFACE CRACK TIP

P. FENG and H. WANG (Institute for Aircraft Structural Strength, People's Republic of China) Acta Mechanica Solida Sinica, Sept. 1985, p. 346-352. In Chinese, with abstract in English. refs

In this paper a new technique of specimen grating copy is described. Combining the technique of spatial filtering, fringe multiplication and image processing, it can be used to measure the elastic-plastic strain field at the curve surface crack tip of axles, pivoting wings, pillar sheets and cone shells. This new technique can even be used to measure the surface strain field of rotary axles, rotary flywheels and rotary wings. Author

**A86-20516#**

### SYNCHRONIZING CHARACTERISTICS OF A LARGE VARIABLE FREQUENCY STARTING SYSTEM

J. K. BRANDON (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) IN: SOUTHEASTCON '84; Proceedings of the Conference, Louisville, KY, April 8-11, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 339-342.

The Aeropropulsion Systems Test Facility (ASTF) is a new jet engine test facility presently under construction by the U.S. Air Force near Tullahoma, Tennessee. The design utilizes a relatively unique variable frequency starting system (VFSS) for startup of the various large electrical drive systems associated with ASTF. During the design phase, one of the major obstacles was to identify the most advantageous method for automatically transferring the large synchronous motors from the VFSS to the main power system. This paper describes the synchronizing techniques and equipment chosen for the ASTF variable frequency starting system. Author

**A86-20638*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### REPEATABILITY OF MIXED-MODE ADHESIVE DEBONDING

R. A. EVERETT, JR. (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) and W. S. JOHNSON (NASA, Langley Research Center, Hampton, VA) IN: Delamination and debonding of materials . Philadelphia, PA, American Society for Testing and Materials, 1985, p. 267-281. Previously announced in STAR as N84-19565. refs

The repeatability of debond growth rates in adhesively bonded subjected to constant-amplitude cyclic loading was studied. Debond growth rates were compared from two sets of cracked-lap-shear specimens that were fabricated by two different manufacturers and tested in different laboratories. The fabrication method and testing procedures were identical or both sets of specimens. The specimens consisted of aluminum adherends bonded with FM-73 adhesive. Critical values of strain-energy-release rate were also determined from specimens that were monotonically loaded to failure. The test results showed that the debond growth rates for the two sets of specimens were within a scatter band which is similar to that observed in fatigue crack growth in metals. Cyclic debonding occurred at strain-energy-release rates that were more than an order of magnitude less than the critical strain-energy-release rate in static tests. Author

**A86-20649**

### THERMOGRAPHIC INSPECTION OF CARBON EPOXY STRUCTURES

D. J. HILLMAN and R. L. HILLMAN (McDonnell Aircraft Co., St. Louis, MO) IN: Delamination and debonding of materials . Philadelphia, PA, American Society for Testing and Materials, 1985, p. 481-493.

In-service damage to composite fighter aircraft structures is normally readily observed visually; often very serious damage can be identified as such by the visual observer. However, it is impossible to see whether or not nondestructive inspection (NDI) is warranted at sites consisting solely of surface scratches and dents because of the possibility of impact damage and other damages which appear superficial but may be significant. The tendency, therefore, has been to quantitatively inspect every dent and scratch observed on composite structures during field NDI to avoid overlooking a serious damage site. The purpose of the efforts reported in this paper is to eliminate this practice by providing a fast, inexpensive, large-area NDI tool capable of screening out superficial damage from serious damage. Author

**A86-20792**

### A NEW METHOD OF ANALYZING WAVE PROPAGATION IN PERIODIC STRUCTURES - APPLICATIONS TO PERIODIC TIMOSHENKO BEAMS AND STIFFENED PLATES

D. J. MEAD (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 104, Jan. 8, 1986, p. 9-27. refs

A response function is found for an infinite, uniform, one-dimensional structure which is subjected to an array of harmonic forces or moments, spaced equidistantly, and which have a constant phase or ratio between any adjacent pair. Receptance functions are derived for these 'phased arrays'. They are used to set up a general determinantal equation for the propagation constants of the infinite structure when it is made periodic by the addition of an infinite set of regular constraints. They are also used to set up equations for the response of the structure to a convected harmonic pressure field. The method enables the equations for the propagation constants and for the response to convected loading to be set up with much greater facility than by earlier methods. It only requires a knowledge of the response function of the infinite uninterrupted structure under a single-point harmonic force or moment. The general equation for the propagation constants is used to study (1) a simply supported periodic Timoshenko beam, and (2) a parallel plate with periodic beam-type stiffeners. Some calculated propagation constants are presented and discussed. The periodic plate results are relevant to integrally stiffened skins of the type used in aeroplanes. Author

**A86-20921**

### A SHARED SATELLITE SYSTEM WOULD SATISFY MANY FUTURE AVIATION NEEDS

J. D. KIESLING and R. E. ANDERSON ICAO Bulletin, vol. 40, Nov. 1985, p. 15-20.

The development of a continental mobile satellite system for aircraft communication is proposed. The system is to provide communication and surveillance for air traffic control and aeronautical operational control. The two-satellite ranging and position fixing of the satellite system are analyzed. The system architecture requires consideration of satellite earth coverage, a frequency and polarization plan, satellite and mobile power and power density, and modulation standards. The use of spot beams and frequency reuse is examined, and diagrams of coverage areas and frequency reuse are presented. Examples of aviation system and mobile satellite system frequency plans are provided.

Differences in satellite characteristics, such as antenna gain, transmitter powers and receiver sensitivities, and mobile antenna gains and powers are discussed. The components and requirements for a typical satellite transponder concept, in particular an aircraft-mounted antenna, are described. I.F.

**A86-21026**

### COMPUTATIONAL METHODS IN VISCOUS FLOWS

W. G. HABASHI, ED. (Concordia University, Montreal, Canada) Swansea, Wales, Pineridge Press (Recent Advances in Numerical Methods in Fluids. Volume 3), 1984, 678 p. For individual items see A86-21027 to A86-21044.

The papers presented in this volume focus on new finite difference and finite element approaches for both incompressible and compressible Navier-Stokes equations, with attention also given to viscous-inviscid interaction problems. Particular topics discussed include some aspects of finite element approximations of incompressible viscous flows, numerical solution of the compressible viscous flow field about a complete aircraft in flight, and finite difference simulation of unsteady interactive flows. Papers are also presented on calculation of separated flows by viscous-inviscid interaction, turbulent flow and heat transfer in coupled solid/fluid systems, and the effect of the solid particle size in two-phase flow around a plane cylinder. V.L.

**A86-21246#**

### A SYNTHETIC APERTURE RADAR (SAR) FOR COMMERCIAL APPLICATIONS

B. L. BULLOCK (Intera Technologies, Ltd., Calgary, Canada) and A. KOZMA (Michigan, Environmental Research Institute, Ann Arbor) IN: International Symposium on Remote Sensing of Environment, 18th, Paris, France, October 1-5, 1984, Proceedings. Volume 3 . Ann Arbor, MI, Environmental Research Institute of Michigan, 1985, p. 1733-1742. refs

Studies leading to the design specifications and subsequent development of a SAR built solely for commercial applications are described. Background searches were made of potential users and their requirements and the corresponding technology. The system developed is called STAR 1 (for Sea-Ice and Terrain Assessment Radar); it is an X-band system installed in a light turboprop aircraft. The data are digitally processed in real time aboard the aircraft and the image is telemetered to a ground station for immediate use. The system is currently operational and has performed a number of tasks including support of arctic drilling and engineering, iceberg detection, arctic transportation, and terrain surveys. D.H.

**A86-21513**

### COMPARISON OF CALCULATED AND MEASURED HEIGHT PROFILES OF TRANSVERSE ELECTRIC VLF SIGNALS ACROSS THE DAYTIME EARTH-IONOSPHERE WAVEGUIDE

E. C. FIELD, JR., C. R. WARBER (Pacific-Sierra Research Corp., Los Angeles, CA), P. A. KOSSEY, E. A. LEWIS, and R. P. HARRISON (USAF, Rome Air Development Center, Bedford, MA) Radio Science (ISSN 0048-6604), vol. 21, Jan.-Feb. 1986, p. 141-149. refs

Airborne VLF antennas radiate energy that propagates via both transverse electric (TE) and transverse magnetic (TM) modes in the earth-ionosphere waveguide. In order to compare the structure of such signals, measurements were made using rocket probes launched from Wallops Island, Virginia. The probes measured TE and TM fields at all altitudes between the ground and the base of the ionosphere. The nearly horizontal airborne transmitting antenna radiated a TE signal that was stronger than its TM signal at altitudes above about 10 km. The signals comprised one or more well-defined TE or TM waveguide modes. Calculated height profiles agree well with the measured ones and correctly reproduce details of profile structure caused by interaction between two or more modes. Author

**A86-21709**

### SPF ALUMINUM - A FIRST FOR THE S-76B HELICOPTER

R. FIORE and M. SCHWARTZ (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 88-96.

Superplastic forming (SPF) of aluminum, basically a low strain rate hot forming process employing specially processed sheet material, permits the forming of complex shapes in one operation usually with considerable cost savings over conventional manufacturing methods. The ability to form complex, one-piece parts is due to the inherent characteristics of the process and the fine grained material which is used. Whereas most metals fracture at strains far below 100 percent, in SPF, elongations of 500-1200 percent are easily obtainable. SPF now provides the manufacturing capability for making complex parts, normally requiring composite lay-ups or welded assemblies, at greatly reduced cost. Sikorsky Aircraft has used this technology, and has received FAA approval to replace two Kevlar and fiberglass parts on the S-76B commercial helicopter at substantial cost savings without a weight penalty or the necessity for a design change. This is the first SPF aluminum production application on an American made helicopter. Author

**A86-21714**

### REQUIREMENTS FOR TAILORING OF MATERIAL PROPERTIES OF VISCOELASTICALLY DAMPED BONDED LAMINATES IN AIRCRAFT STRUCTURES

K. B. SANGHA and S. N. VACCA (LTV Aerospace and Defense Co., Vought Aero Products Div., Dallas, TX) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 135-146. refs

Adhesively bonded laminates have been used for several years in the aerospace industry. Over two decades ago, their potential as noise and vibration damping mechanisms was recognized. With major new advances in materials and processes technology of adhesives, one is confronted with a plethora of adhesives that can be used for an application. This paper outlines some requirements of adhesive properties to be effective damping materials. Parameter variations are used to emphasize the importance of optimal selection of the dynamic properties of an adhesive for each application. The influence of frequency, temperature and strain amplitude is recapitulated, and their relative influences are delineated. The influence of altering the quantity of some constituents of an adhesive on damping effectiveness is presented through test data. Author

**A86-21826**

### SYMPOSIUM GYRO TECHNOLOGY 1984; PROCEEDINGS OF THE SYMPOSIUM, UNIVERSITAET STUTTGART, WEST GERMANY, SEPTEMBER 11, 12, 1984

H. SORG, ED. (Stuttgart, Universitaet, West Germany) Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1984, 455 p. For individual items see A86-21827 to A86-21843.

Among the topics discussed are: drift and scale factor tests on the SEL fiber gyro; integrated optical rate sensor development; and the beam geometry of a ring laser gyro in relation to its performance. Consideration is also given to: a fast filtering technique for measuring random walk in a laser gyro; vibratory gyroscopic sensors; a redundant strapdown reference for advanced aircraft flight control systems; and a low-cost piezoelectric rate/acceleration sensor. Additional topics include: an inertial guidance system for a Low-Earth-Orbit (LEO) vehicle; and signal disturbance effects in a strapdown northfinder. I.H.

**A86-21891**

**AIRBORNE COMMUNICATIONS RECONSTITUTION EXPERIMENTS**

G. A. DESBRISAY, B. C. FAIR, and M. S. FRANKEL (SRI International, Advanced Information-Technology Applications Center, Menlo Park, CA) IN: EASCON '84; Proceedings of the Seventeenth Annual Electronics and Aerospace Conference, Washington, DC, September 10-12, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 311-319. refs

As a result of the development of advanced modern weapon systems and the high mobility of forces during battle, military forces will face a highly dynamic environment in future confrontations. The present paper is concerned with investigations regarding a survivable, Strategic Air Command (SAC) Command and Control environment. The environment considered depends upon a highly survivable communication system and upon redundantly distributed, automatically updated databases. In mid-1980, the Strategic Command, Control, and Communications (CCC) Testbed was created. The network technologies which are being developed in the CCC Testbed are rapidly approaching the point where they can provide the required capabilities. G.R.

**A86-21895#**

**CAD/CAM DESIGNER - JACK OF ALL TRADES**

C. F. HERNDON and R. L. GALLO (General Dynamics Corp., Fort Worth, TX) Aerospace America (ISSN 0740-722X), vol. 24, Jan. 1986, p. 52-54, 56.

Aerospace design engineers are increasingly required to have more extensive knowledge of CAD/CAM tooling and manufacturing methods, in order to ensure that datasets can yield error-free components and assemblies. For structural concept design, engineers will work at the same CAD/CAM workstation on which the final component will be defined, controlling methods that yield the optimum solution for each member of a structural system from the viewpoints of both weight (for given strength) and producibility. O.C.

**A86-21996*** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

**MEASUREMENTS OF ROTATING BUBBLE SHAPES IN LOW-GRAVITY ENVIRONMENT**

F. LESLIE (NASA, Marshall Space Flight Center, Huntsville, AL) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 161, Dec. 1985, p. 269-279. NASA-supported research. refs

Measurements of rotating equilibrium bubble shapes in the low-gravity environment of a free-falling aircraft are presented. Emphasis is placed on bubbles which intersect the container boundaries. These data are compared with theoretical profiles derived from Laplace's formula and are in good agreement with the measurements. The interface shape depends on the contact angle, the radius of intersection with the container, and the parameter F, which is a measure of the relative importance of centrifugal force to surface tension. For isolated bubbles F has a maximum value of 1/2. A further increase in F causes the bubble to break contact with the axis of rotation. For large values of F the bubble becomes more cylindrical and the capillary rise occurs over a thinner layer in order that the small radius of curvature can generate a sufficient pressure drop to account for the increased hydrostatic contribution. Author

**A86-22035#**

**FULL COVERAGE DISCRETE HOLE FILM COOLING - THE INFLUENCE OF HOLE SIZE**

G. E. ANDREWS, A. A. ASERE, M. L. GUPTA, and M. C. MKPADI (Leeds, University, England) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 8 p. refs

(Contract SERC-GR/B/00336; SERC-GR/B/67827)

(ASME PAPER 85-GT-47)

The influence of hole size and hence blowing rate on full coverage discrete hole wall cooling for gas turbine combustion chamber applications was investigated. Two temperature conditions were used first, a 750 K gas temperature and 300 K coolant, and secondly a realistic combustor primary zone conditions of 2100 K flame temperature and 700 K coolant. It was shown that a large hole size resulted in a significant improvement in the overall cooling effectiveness due to a reduced film heat transfer coefficient. At high temperature the cooling effectiveness was reduced due to radiative heat transfer from the flame gases. At low coolant flow large temperature increases of the coolant occurred within the wall and approached the transpiration situation. Author

**A86-22054*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**A REVIEW AND ANALYSIS OF BOUNDARY LAYER TRANSITION DATA FOR TURBINE APPLICATION**

R. E. GAUGLER (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 8 p. Previously announced in STAR as N85-10306. refs

(ASME PAPER 85-GT-83)

A symposium on transition in turbines was held at the NASA Lewis Research Center. One recommendation of the working groups was the collection of existing transition data to provide standard cases against which models could be tested. A number of data sets from the open literature that include heat transfer data in apparently transitional boundary layers, with particular application to the turbine environment, were reviewed and analyzed to extract transition information from the heat transfer data. The data sets reviewed cover a wide range of flow conditions, from low speed, flat plate tests to full scale turbine airfoils operating at simulated turbine engine conditions. The results indicate that free stream turbulence and pressure gradient have strong, and opposite, effects on the location of the start of transition and on the length of the transition zone. R.S.F.

**A86-22056#**

**INTERDEPENDENCE OF CENTRIFUGAL COMPRESSOR BLADE GEOMETRY AND RELATIVE FLOW FIELD**

H. KRAIN (DFVLR, Institut fuer Antriebstechnik, Cologne, West Germany) ASME, International Gas Turbine Conferences and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. refs

(ASME PAPER 85-GT-85)

The influence of the impeller blade geometry on the calculated relative flow field has been studied by means of an impeller design program available at DFVLR (Krain, 1984). Several geometrical parameters were varied, however, the meridional channel geometry was always kept constant. By this approach the blade wrap angle has been found to react significantly on the relative flow which is illustrated by comparing two designs with different wrap angles. Primarily in the hub/leading edge area a better boundary layer flow connected with a reduction of blade loading was obtained by increasing the wrap angle. But also in the shroud/pressure side area the increased blade looping attributed to an additional flow stabilization. Author

**A86-22070#**

**HEAT TRANSFER MEASUREMENTS WITH FILM COOLING ON A TURBINE BLADE PROFILE IN CASCADE**

F. G. HORTON, D. L. SCHULTZ (Oxford University, England), and A. E. FOREST (Rolls-Royce, Ltd., Derby, England) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 10 p. Research supported by the Ministry of Defence (Procurement Executive) and Rolls-Royce, Ltd. refs

(ASME PAPER 85-GT-117)

Heat transfer measurements with film cooling have been made on a gas turbine rotor profile in a cascade at engine representative operating conditions. The blade temperature was varied independently to investigate the scaling of heat transfer coefficient, and a superposition model was found to correlate the data. Contrasting results are presented for films on the two surfaces, along with predictions from a two-dimensional boundary layer method. Author

**A86-22071#**

**INVERSE DESIGN OF COOLANT FLOW PASSAGE SHAPES WITH PARTIALLY FIXED INTERNAL GEOMETRIES**

S. R. KENNON and G. S. DULIKRAVICH (Texas, University, Austin) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 10 p. refs

(ASME PAPER 85-GT-118)

A method has been developed for the design and analysis of complex coolant flow passage shapes in internally cooled turbine engines. The method is particularly applicable to turbine airfoil cascade inverse design but may also be applied to the design of other nonadiabatic boundaries such as missile cone tips and internal combustion engine cylinder. The method makes it possible to specify and fix the temperature or the heat flux at the turbine airfoil outer surface, together with the desired temperature at the coolant/blade interfaces. Coupled with an appropriate flow solver and stress analysis code, the method provides accurate estimates of the blade surface temperature and heat flux distribution in the coolant passage. A first order panel method is used to solve the Laplace equations for steady heat conduction within the solid portions of the hollow blade. In order to illustrate the efficiency of the method, numerical results are presented for the case of a turbine airfoil having three coolant holes. The discretized temperature contours for the inner and outer parts of the blade are illustrated in graphic form. I.H.

**A86-22073#**

**DEVELOPMENT OF A DESIGN MODEL FOR AIRFOIL LEADING EDGE FILM COOLING**

A. R. WADIA and D. A. NEALY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 12 p. refs

(ASME PAPER 85-GT-120)

A series of experiments on scaled cylinder models having injection through holes inclined at 20, 30, 45, and 90 degrees are presented. The experiments were conducted in a wind tunnel on several stainless steel test specimens in which flow and heat transfer parameters were measured over simulated airfoil leading edge surfaces. On the basis of the experimental results, an engineering design model is proposed that treats the gas-to-surface heat transfer coefficient with film cooling in a manner suggested by Luckey and L'Ecuyer (1981). It is shown that the main factor influencing the averaged film cooling effectiveness in the showerhead region is the inclination of the injection holes. The effectiveness parameter was not affected by variations in the coolant-to-gas stream pressure ratio, the freestream Mach number, the gas to coolant temperature ratio, or the gas stream Reynolds number. Experience in the wind tunnel tests is reflected in the design of the model in which the coolant side heat transfer coefficient is offset by a simultaneous increase in the gas side film coefficient. The design applications of the analytical model are discussed, with emphasis given to high temperature first stage turbine vanes and rotor blades. I.H.

**A86-22084*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**NASA LEWIS RESEARCH CENTER/UNIVERSITY GRADUATE RESEARCH PROGRAM ON ENGINE STRUCTURES**

C. C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 10 p. Previously announced in STAR as N85-18375.

(ASME PAPER 85-GT-159)

NASA Lewis Research Center established a graduate research program in support of the Engine Structures Research activities. This graduate research program focuses mainly on structural and dynamics analyses, computational mechanics, mechanics of composites and structural optimization. The broad objectives of the program, the specific program, the participating universities and the program status are briefly described. Author

**A86-22099#**

**INVESTIGATION OF JET-FILMING AIRBLAST ATOMIZER**

Q.-S. ZHAO and Y.-F. YU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 7 p. refs

(ASME PAPER 85-GT-185)

The jet-filming airblast atomizer is another kind of airblast atomizer differing from a prefilming airblast atomizer. Its atomizing mechanism and performance were investigated experimentally and theoretically. The effects of design parameters on the mean droplet size SMD and the thickness of the liquid film were obtained. The inherent mechanism consisting of three atomizing processes was proved. From this, the performance curves of atomization and thickness of liquid film can be explained and the principles of design of this kind of atomizer were derived. The results obtained show that the performance of the jet-filming airblast atomizer is better than that of the prefilming type, and it is simple in design. So it is advantageous to apply this kind of atomizer to an advanced aircraft engine. Author

**A86-22134#**

**STRUCTURAL AND MATERIAL CONSIDERATIONS FOR ADVANCED FIGHTERS**

T. R. ROONEY (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 8-1 to 8-6.

Current and emerging structural technologies provide the opportunity to make a quantum jump in the design of next generation aircraft. The impact of new materials and structural concepts on the performance, producibility and life cycle costs of advanced fighters is discussed. The expected applications of advanced materials tehnologies in metallics, composites and hybrid structures are described. Author

**A86-22142#**

**SUPERPLASTICALLY-FORMED/DIFFUSION-BONDED M TECHNOLOGY TRANSITION CASE STUDY**

E. D. BOUCHARD and J. P. SORENSEN (McDonnell Aircraft Co., St. Louis, MO) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 19-1 to 19-4.

The principles of the superplastic forming/diffusion bonding (SPF/DB) of titanium and of the low-cost structural concepts employed in the new F-15E aft fuselage are described. Application of the SPF/DB of Ti technology in the F-15E aft fuselage provides a good case study in the transition of the SPF/DB Ti research and development program from laboratory scale to production state. It is shown that use of the new technology will result in a significant reduction of acquisition cost, life-cycle costs, reduction in structural weight, and improved durability and will open the door for further application on new aircraft, such as the Advanced Tactical Fighter. I.S.

**A86-22143#**

**TRANSITION OF ADVANCED MATERIALS AND STRUCTURES - SINGLE CRYSTAL BLADES**

M. M. ALLEN and D. S. HALFPAP (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 20-1 to 20-4.

The paper discusses the generic path of manufacturing technology R&D implementation using single crystal turbine blades as an example. Single crystal turbine airfoils represent an evolutionary outgrowth of P&W developed directional solidification process which significantly contributed to gas turbine fuel efficiency and performance. The following key elements of implementation are dsicussed: Technology payoff, laboratory specimen and rig testing; engine testing and transition to production. Author

**A86-22144#**

**COMPOSITES TECHNOLOGY TRANSFER AND TRANSITION**

D. REED (General Dynamics Corp., Fort Worth, TX) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 21-1 to 21-4.

This paper gives a brief overview of General Dynamics' involvement in composites manufacturing since 1964; the development of tape-laying machine technology; and the transfer and transition of that technology throughout industry. Special emphasis is given to the importance to the aircraft industry of Technology Modernization and Manufacturing Technology programs in providing incentives for composites technology development. Author

**A86-22178**

**IMPLICATIONS OF NEW AIRCRAFT AVIONICS RELIABILITY PERFORMANCE**

M. E. MOORHEAD (Rockwell International Corp., Collins Div., Melbourne, FL) IN: Environmental integration technology today for a quality tomorrow; Proceedings of the Thirtieth Annual Technical Meeting, Orlando, FL, May 1-3, 1984 . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 232-235.

An evaluation is made of MTBF values projected for avionics operating under environmental conditions typical of state-of-the-art 'digital' aircraft. Equipment reliability levels obtained during the fist year of operational experience with the B 767 and B 757 airliners are presented and compared with levels characteristic of previous avionic failure rates. Theoretical reliability levels based on existing MIL-HDBK-217 failure rate curves and acceleration factors are related to demonstrated performance levels, in order to identify points of correlation as well as discrepancies. O.C.

**A86-22192**

**THE AIR FORCE APPROACH TO ENVIRONMENTAL STRESS SCREENING**

E. J. WESTCOTT (USAF, Systems Command, Andrews AFB, MD) IN: Environmental integration technology today for a quality tomorrow; Proceedings of the Thirtieth Annual Technical Meeting, Orlando, FL, May 1-3, 1984 . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 385, 386.

Use of environmental stress screening (ESS) by the USAF Systems Command to improve the quality of the systems and decrease the life-cycle costs of systems acquisition and development is described. A military ESS standard, which will provide for tailoring and application, is being developed and will be issued in 1984 for the use of ESS on all systems during full-scale development and production phases. Cost-effective tailoring and selection of such stress levels, which will stimulate failure modes consistent with the expected use environment, will be continually monitored. Combined environmental reliabilty (CERT) testing will be used as a basis for TAAF, reliability demonstration, and reliability acceptance. I.S.

**A86-22318#**

**CALCULATION OF MISALIGNMENT ERROR OF MULTI-JOINT HOLES OF WING TO FUSELAGE**

Z. CUI (Shenyang Aircraft Corp., People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Aug. 1985, p. 385-392. In Chinese, with abstract in English.

An error dimensional chain equation for misalignment of multijoint holes of wing to fuselage is discussed in this paper. The equation is derived on the basis of error dimensional chain theory and according to the principle that between any two points a straight line may be drawn, but among more than two points only a broken line can be made. This equation can estimate the coaxiality of joints and the misalignment error in the center location of fork-ear fitting. Therefore, some suggestions for improvement of unjust joining specifications are offered and the evaluation of construction compensation is given. Author

**A86-22382**

**THE AUTOMATED, ADVANCED MATRIX FMEA TECHNIQUE**

P. L. GODDARD and R. W. DAVIS (Hughes Aircraft Co., Fullerton, CA) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 77-81.

It is pointed out that the Failure Modes and Effects Analysis (FMEA) is one of the most effective design analysis techniques used in reliability engineering. Thus, a properly performed FMEA can be used to support a wide range of analyses and disciplines. However, FMEA is expensive to perform, and it requires the use of one or more highly skilled analysts. In addition, MIL-STD-1629A, representing tabular FMEA documentation, is not organized in a way which would permit the maximum effective use of all analysis results. The present paper is concerned with the Advanced Matrix Technique which provides a solution to several of the major problems with FMEA. The Advanced Matrix Technique was developed as part of a study of automated FMEA techniques. Attention is given to the objectives of the Advanced Matrix Technique, aspects of technical structure, technical phasing, and the Failure Effects and Data Synthesis computer program, which was developed to automate the Advanced Matrix FMEA technique. G.R.

**A86-22384**

**MAINTENANCE STRATEGIES FOR AERO ENGINES**

J. K. BLUNDELL (Missouri, University, Columbia) and K. W. BEARD (Trans World Airlines, Kansas City, MO) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 92-98. refs

In the planned replacement of aero engines, common strategies employ time dependent or block replacement methods. Neither can produce optimal strategies as components tend to be replaced unnecessarily, the beauty of the systems are that they are easy to plan although the number of maintenance actions are often excessive. The paper addresses the development of an opportunistic maintenance strategy for the RB 211 commercial airplane engine which develops planned replacements based on system and component reliabilities and which can interactively determine least cost replacement modes at predetermined inspection intervals. Author

**A86-22391#**

**RELATING FACTORY AND FIELD RELIABILITY AND MAINTAINABILITY MEASURES**

P. R. MACDIARMID (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 177-183. refs

This paper addresses the issue of field reliability not equaling factory reliability. It overviews Air Force and DOD policy on the issue, reviews previous works on the subject and details current Rome Air Development Center activities related to it, including a recently completed study that developed models translating contractual to operational (and vice versa) R&M parameters. Author

**A86-22396**

**HARDWARE/SOFTWARE FMEA APPLIED TO AIRPLANE SAFETY**

J. B. J. VAN BAAL (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Annual Reliability and Maintainablity Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 250-255.

Recent changes in the nature of airplane systems have created the need for a systematical and analytical methodology for system safety assessment. Such a methodology is briefly explained. A try-out on a software controlled digital avionics system is described. Special attention is paid to the analysis of the software components of the system. From this work it is concluded that the same methodology can be applied to both software and hardware. Two conditions that have to be met to perform a successful hardware/software safety assessment are described. Author

**A86-22402**

**IS THERE LIFE AFTER 10,000 FLIGHT HOURS?**

T. M. EVANS and D. L. MERKORD (LTV Aerospace and Defense Co., Dallas, TX) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 396-401.

(Contract N00019-80-G-0033; NAVY ORDER 0002)

The possibility of keeping an aircraft in service beyond the predetermined fatigue life limits of its structures is considered, with particular reference to the fleet of A-3 aircraft, which exceeded their wing design fatigue life of 10,000 flight hours. Fatigue test/analysis on an A-3 trainer model is described, including discussions of test requirements, development of the fatigue test loading spectrum, the test setup, and testing procedure. It was found that service life of A-3 fleet aircraft can be extended to 18,000 flight hours and 2000 catapults. The test data verified that theoretical analyses for service life extension are reliable when fatigue-test-derived maintainability items are applied. I.S.

**A86-22407**

**A MULTIPLE-PARAMETER ALLOCATION PROCESS**

C. E. TUCKER (Lockheed-Georgia Co., Marietta, GA) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 448-453.

An allocation process has been developed to produce realistic component level requirements on multiple reliability and maintainability (R and M) parameters. The process simultaneously allocates a set of multiple key parametric constraints which are translatable from requirements on parameters such as Weapon System Reliability (WSR), Mean Time Between Removals (MTBR), Maintenance Manhours per Flight Hour (MMH/FH), Mean Manhours to Repair (MMH/R), and Availability. Using component and system total predictions and improvability estimates, the process iteratively selects and allocates incremental improvements to the key parameters and components in need of greatest further improvement to achieve air vehicle or system total requirements, and related parameters are allocated improvements proportional to these. The iterative algorithm, which resembles the method of steepest descent, terminates when all key requirements have been met by the sum total of all incremental improvements selected. A brief example is included which reveals the essential features of the process. Author

**A86-22681*#** Amtec Engineering, Inc., Bellevue, Wash.

**NUMERICAL SOLUTION OF 2-D THRUST REVERSING AND THRUST VECTORING NOZZLE**

S. IMLAY (Amtec Engineering, Inc., Bellevue, WA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs

(Contract NAS1-17170)

(AIAA PAPER 86-0203)

The flowfield within and around two dimensional thrust reversing and thrust vectoring nozzles has been calculated using a new unfactored implicit method with a multiple zone grid. Computations are done for fully deployed thrust reversing nozzles, partially deployed thrust reversing nozzles with thrust vectoring, and a nozzle transitioning from partially to fully deployed. Agreement with available experimental data is good. Author

**A86-22684#**

**COUPLING ARTIFICIAL INTELLIGENCE AND NUMERICAL COMPUTATION FOR ENGINEERING DESIGN (INVITED PAPER)**

S. S. TONG (General Electric Co., Schenectady, NY) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p. refs

(AIAA PAPER 86-0242)

The possibility of combining artificial intelligence (AI) systems and numerical computation methods for engineering designs is considered. Attention is given to three possible areas of application involving fan design, controlled vortex design of turbine stage blade angles, and preliminary design of turbine cascade profiles. Among the AI techniques discussed are: knowledge-based systems; intelligent search; and pattern recognition systems. The potential cost and performance advantages of an AI-based design-generation system are discussed in detail. I.H.

**A86-22690*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**QUANTITATIVE DETERMINATION OF ENGINE WATER INGESTION**

P. PARIKH, M. HERNAN, and V. SAROHIA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(Contract NAS7-918; DOT-FA03-81-A-00765)

(AIAA PAPER 86-0307)

This paper describes a novel non-intrusive optical technique for determination of liquid mass flux in a droplet laden airstream. The technique was developed for quantitative determination of engine water ingestion resulting from heavy rain or wheel spray. Independent measurements of the liquid water content (LWC) of the droplet laden aircraft and of the droplet velocities were made at the simulated nacelle inlet plane for the liquid mass flux determination. The liquid water content was measured by illuminating and photographing the droplets contained within a thin slice of the flow field by means of a sheet of light from a pulsed YAG laser. A fluorescent dye introduced in the water greatly improved the droplet image definition. The droplet velocities were determined from double exposed photographs of the moving droplet field. The technique was initially applied to a steady spray generated in a wind tunnel. It was found that although the spray was initially steady, the aerodynamic breakup process was inherently unsteady. This resulted in a wide variation of the instantaneous liquid water content of the droplet laden airstream. The standard deviation of ten separate LWC measurements was 31 percent of the average. However, the liquid mass flux calculated from the average LWC and droplet velocities came within 10 percent of the known water ingestion rate. Author

**A86-22700*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FORMATION AND CHARACTERIZATION OF SIMULATED SMALL DROPLET ICING CLOUDS**

R. D. INGEBO (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. Previously announced in STAR as N86-14554.

(AIAA PAPER 86-0409)

Two pneumatic two-fluid atomizers operating at high liquid and gas pressures produced water sprays that simulated small droplet clouds for use in studying icing effects on aircraft performance. To measure median volume diameter, MVD or D sub v.5, of small droplet water sprays, a scattered-light scanning instrument was developed. Drop size data agreed fairly well with calculated values at water and nitrogen pressures of 60 and 20 psig, respectively, and at water and nitrogen pressures of 250 and 100 psig, respectively, but not very well at intermediate values of water and nitrogen pressure. MVD data were correlated with D sub O, W sub N, and W sub w, i.e., orifice diameter, nitrogen, and water flowrate, respectively, to give the expression for MVD in microns. Author

**A86-22703*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.
**DUAL RECTANGULAR JETS FROM A FLAT PLATE IN A CROSSFLOW**
M. KAVSAOGLU, J. A. SCHETZ, and A. K. JAKUBOWSKI (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. NASA-supported research. refs
(AIAA PAPER 86-0477)

Wind tunnel tests were carried out in order to study the single and dual rectangular crossflow jets injected from a flat plate perpendicular to a free stream. The length-to-width ratio of the jets was 3.97, and the spacing between the center lines was 4.7 times the width of a single jet. Surface pressure distributions were obtained for jet-to-freestream velocity ratios of 2.2 and 4, respectively. The following conclusions are offered on the basis of the experimental results: (1) the downstream extension of the negative pressures is extended to the dual jets in comparison to the single jet; (2) by increasing the jet-to-freestream velocity ratio the downstream extension of negative pressures is reduced, but negative upstream pressures become larger; (3) very high peak negative pressures occur at the front side edges of the rectangular jets compared to round jets. Velocity vector plots in the flowfield of the dual jets are given. I.H.

**N86-16428#** Transportation Research Board, Washington, D.C.
**SURFACE PROPERTIES-VEHICLE INTERACTION**
D. L. HUFT, I. HER, S. K. AGRAWAL, R. A. ZIMMER, and C. J. BESTER 1984 62 p
(PB85-242576; TRB/TRR-1000; ISBN-0-309-03809-X; LC-85-10046) Avail: NTIS HC A04/MF A01 CSCL 13B

Several topics related to the surface properties of aircraft runways are discussed. The South Dakota profilometer; development of a data acquisition method for noncontact pavement macrotexture measurement; the traction of an aircraft tire on grooved and porous asphaltic concrete; holes in the pavements; the effect of pavement type and condition on the fuel consumption of vehicles; the traction loss of a suspended tire on a sinusoidal road; the effect of vehicle and driver characteristics on the psychological evaluation of road roughness; the correlation of subjective panel ratings of pavement ride quality with profilometer-derived measures of pavement roughness; a microprocessor-based noncontact distance measuring control system, and, the representation of pavement surface topography in predicting runoff depths and hydroplaning potential are discussed. DOE

**N86-16486*#** ALPHATECH, Inc., Burlington, Mass.
**ROBUST DETECTION-ISOLATION-ACCOMMODATION FOR SENSOR FAILURES Final Report**
J. L. WEISS, K. R. PATTIPATI, A. S. WILLSKY, J. S. ETERNO, and J. T. CRAWFORD Sep. 1985 220 p refs
(Contract NAS3-24078)
(NASA-CR-174797; NAS 1.26:174797; TR-213-1) Avail: NTIS HC A10/MF A01 CSCL 09C

The results of a one year study to: (1) develop a theory for Robust Failure Detection and Identification (FDI) in the presence of model uncertainty, (2) develop a design methodology which utilizes the robust FDI ththeory, (3) apply the methodology to a sensor FDI problem for the F-100 jet engine, and (4) demonstrate the application of the theory to the evaluation of alternative FDI schemes are presented. Theoretical results in statistical discrimination are used to evaluate the robustness of residual signals (or parity relations) in terms of their usefulness for FDI. Furthermore, optimally robust parity relations are derived through the optimization of robustness metrics. The result is viewed as decentralization of the FDI process. A general structure for decentralized FDI is proposed and robustness metrics are used for determining various parameters of the algorithm. Author

**N86-16521#** Calspan Field Services, Inc., Arnold AFS, Tenn.
**INVESTIGATION OF THE DEVELOPMENT OF LAMINAR BOUNDARY-LAYER INSTABILITIES ALONG A SHARP CONE Final Report, 12 - 15 Feb. 1985**
J. C. DONALDSON and S. A. SIMONS Apr. 1985 62 p
Sponsored by Air Force
(AD-A159370; AEDC-TSR-85-V16) Avail: NTIS HC A04/MF A01 CSCL 20D

Measurements of mean-flow and fluctuating flow parameters were made in the boundary layer on a sharp 7-deg cone in an investigation of the stability of laminar boundary layers. The flow fluctuation measurements were made using hot-wire anemometry techniques. Flow field profiles and model surface conditions were also measured. The testing was performed at a free-stream Mach number of 8 for free-stream Unit-Reynolds numbers of 1.0, 2.0, and 3.0-million per foot. The test equipment and techniques and the data acquisition and reduction procedures are described. Analysis of the hot-wire anemometer data is beyond the scope of this report. GRA

**N86-16553*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**IMAGE PROCESSING OF AERODYNAMIC DATA**
N. D. FAULCON Dec. 1985 15 p refs
(NASA-TM-87629; NAS 1.15:87629) Avail: NTIS HC A02/MF A01 CSCL 14B

The use of digital image processing techniques in analyzing and evaluating aerodynamic data is discussed. An image processing system that converts images derived from digital data or from transparent film into black and white, full color, or false color pictures is described. Applications to black and white images of a model wing with a NACA 64-210 section in simulated rain and to computed low properties for transonic flow past a NACA 0012 airfoil are presented. Image processing techniques are used to visualize the variations of water film thicknesses on the wing model and to illustrate the contours of computed Mach numbers for the flow past the NACA 0012 airfoil. Since the computed data for the NACA 0012 airfoil are available only at discrete spatial locations, an interpolation method is used to provide values of the Mach number over the entire field. Author

**N86-16595#** Rolls-Royce Ltd., Derby (England).
**THE TECHNICAL DEVELOPMENT OF COOLED GAS TURBINE BLADES**
S. ROBBINS and H. TUBBS 23 Jul. 1985 85 p refs
(PNR-90292) Avail: NTIS HC A05/MF A01

The history of cooling technology development within Rolls Royce is presented. A list of patents is given. The described systems include those of Conway, Dart, Tyne, Spey and Avon engines. The technical problems related to cost, weight, stress, vibration and performance are discussed. Author (ESA)

**N86-16611*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**MASS BALANCING OF HOLLOW FAN BLADES**
R. E. KIELB 1986 15 p refs Proposed for presentation at the 31st International Gas Turbine Conference, Dusseldorf, West Germany, 8-12 Jun. 1985; sponsored by ASME
(NASA-TM-87197; E-2851; NAS 1.15:87197) Avail: NTIS HC A02/MF A01 CSCL 20K

A typical section model is used to analytically investigate the effect of mass balancing as applied to hollow, supersonic fan blades. A procedure to determine the best configuration of an internal balancing mass to provide flutter alleviation is developed. This procedure is applied to a typical supersonic shroudless fan blade which is unstable in both the solid configuration and when it is hollow with no balancing mass. The addition of an optimized balancing mass is shown to stabilize the blade at the design condition. Author

**N86-16613#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STRESS ANALYSIS OF 27% SCALE MODEL OF AH-64 MAIN ROTOR HUB**

R. V. HODGES Oct. 1985 49 p refs

(NASA-TM-87625; NAS 1.15:87625; AVSCOM-TR-85-B-8) Avail: NTIS HC A03/MF A01 CSCL 01C

Stress analysis of an AH-64 27% scale model rotor hub was performed. Component loads and stresses were calculated based upon blade root loads and motions. The static and fatigue analysis indicates positive margins of safety in all components checked. Using the format developed here, the hub can be stress checked for future application. Author

**N86-16616#** Shock and Vibration Information Center (Defense), Washington, D. C.

**THE SHOCK AND VIBRATION BULLETIN 55. PART 1: WELCOME, KEYNOTE ADDRESS, INVITED PAPERS, ISOLATION AND DAMPING AND DAMPING PRACTICES Monthly Report**

Jun. 1985 169 p refs Proceedings of the 55th Symposium on Shock and Vibration, Dayton, Ohio, 22-24 Oct. 1984; sponsored by AFSD 3 Vol.

(AD-A160263; SVIC-BULL-55-PT-1) Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

Presented are the welcome address and the keynote address for the 55th symposium on shock and vibration. Also in this section appears invited papers on reliability, damping practics, and damping and isolation. Some article topics include: (1) Avionics Integrity Program (AVIP) air force thrust for reliability; (2) a decade of reliability testing; (3) a different view of viscous damping; (4) passive damping, sonic fatigue and the KC-135; (5) passive load control dampers; and (6) vibration and damping analysis of curved sandwich panels.

**N86-16617#** Aeronautical Systems Div., Wright-Patterson AFB, Ohio.

**AVIP AIR FORCE THRUST FOR RELIABILITY**

J. C. HALPIN *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 5-19 Jun. 1985

Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 14D

An overview is given of the avionics integrity program. Some history is given as to how and why the program developed. The program concerns itself with the quality assurance and reliability of aircraft electronics. It is believed that the safety of avionics can be controlled by controlling the flaw size distribution and stress levels. Also preventive maintenance is briefly discussed. E.R.

**N86-16618#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**DYNAMICS R AND D IN THE AFWAL STRUCTURES AND DYNAMICS DIVISION**

J. J. OLSEN *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 21-27 Jun. 1985

Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

A brief overview of the recent accomplishments, current activities and plans for in-house R&D, contractual R&D and systems support in structural dynamics by the Air Force Wright Aeronautical Laboratories are given. Areas of specific concern are survivable structure, advanced aeronautical structural concepts, aircraft structural integrity, spacecraft structures, and structures and dynamics technology base. Several facilities for research and development in structural dynamics are briefly described. Author

**N86-16619#** LTV Aerospace and Defense Co., Dallas, Tex. Missiles and Advanced Programs Div.

**A DECADE OF RELIABILITY TESTING PROGRESS**

R. N. HANCOCK *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 29-41 Jun. 1985 refs

Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 14D

At the 45th shock and vibration symposium, which was held at the Dayton Convention Center in 1974, the S&V community was alerted to problems that existed in avionics reliability. A two year study described problems and some proposed fixes. The Air Force programs investigated many actions which are still in progress. The progress that has been made toward the solutions that were proffered at the 1974 meeting are reviewed and some of the tasks that still need development are listed. The problems that were disclosed in 1974 fell into both the technical and the administrative arenas. The latter will be mentioned where lack of action interferes with technical progress, the primary topic. Author

**N86-16620#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**CERT: WHERE WE HAVE BEEN, WHERE WE ARE GOING**

A. BURKHARD *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 43-49 Jun. 1985

Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 14D

Combined Environment Reliability Test (CERT) is discussed where it has been and where the technology is going. What led to the development of this technology is discussed, what has been accomplished, and then what kind of activities and ideas are underway to move beyond CERT. Why was it necessary to develop the concept now called CERT? What is CERT? A thumbnail tutorial on the development of CERT is given, the engineering process one goes through to develop a CERT profile and finally how one might go about applying CERT in a contractual situation. The technology perception challenges that the development and validation of CERT uncovered is described. These are the areas that future development and focus of development efforts need to be undertaken. Author

**N86-16625#** Dayton Univ., Ohio. Research Inst.

**PASSIVE DAMPING, SONIC FATIGUE AND THE KC-135A**

P. A. GRAF, M. L. DRAKE, M. P. BOUCHARD, and R. J. DOMINIC *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 89-101 Jun. 1985 refs

Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

High noise levels occurring during maximum thrust takeoff have caused sonic fatigue cracking of the aft fuselage skin and stringers of the KC-135A aircraft. A program was conducted to solve this problem through the design and evaluation of a passive damping system for the aft fuselage of the KC-135A. A detailed description of the program results is presented. Author

**N86-16627#** Dayton Univ., Ohio. Rsearch Inst.

**A DIFFERENT APPROACH TO DESIGNED IN PASSIVE DAMPING**

M. L. DRAKE *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 109-117 Jun. 1985 refs

Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

In the past, most damping applications were additive designs used to solve field problems. Today, designers are beginning to consider integral (designed in) damping systems. This change in emphasis in damping design will change the market in damping materials. Soon the damping material vendor will be supplying damping materials in bulk form (sheets, rolls, uncured gum) to the structural system manufacturers. Since the damping materials will be required in bulk form, the possibility of ordering a custom formulated material exists. A method is demonstrated which

develops the required damping material properties, discuss formulation changes usable to adjust the damping material properties, and discuss the benefits of such design procedures.
Author

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**N86-16646#** Shock and Vibration Information Center (Defense), Washington, D. C.
**THE SHOCK AND VIBRATION BULLETIN 55. PART 2: DYNAMIC TESTING, FLIGHT VEHICLE DYNAMICS, SEISMIC LOADS AND FLUID-STRUCTURE INTERACTION Monthly Report**
Jun. 1985 202 p refs Proceedings of the 55th Symposium on Shock and Vibration, Dayton, Ohio, 22-24 Oct. 1984; sponsored by ASD 3 Vol.
(AD-A160264; SVIC-BULL-55-PT-2) Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 01C

Several topics related to dynamic testing, flight dynamics, seismic loads, and fluid-structure interaction are discussed. Shock waves, earthquakes, impact tests, blast loads, aircraft reliability, ship hulls, and submerged bodies are among the topics covered.

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**N86-16647#** Pacific Missile Test Center, Point Mugu, Calif.
**TRIAXIAL VIBRATION SYSTEM**
W. D. EVERETT and T. H. HELFRICH *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 2 p 1-15 Jun. 1985 refs
Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

During the reliability tests of external stores the Pacific Missile Test Center has been successful in reproducing the in-service vibration experienced by the store when carried on a high performance jet aircraft. A combination of acoustic and mechanical excitation provides the appropriate vibration magnitude and spectrum. One of the advantages of using acoustic energy has been the simulation of the vibrational state simultaneously in three axes. In attempting to increase test capability to include stores carried on helicopters and other low speed platforms and to maintain a triaxial vibration capability, Pacific Missile Test Center is developing a test facility that will test a 500 pound store in the 0 to 500 Hertz frequency range with a stroke of 2 inches double amplitude. A review of existing low frequency triaxial vibration equipment was conducted, a preliminary design was completed, and individual component and initial developmental model tests were concluded. A description of the device, an overview of the effort to date, an analytical investigation of the motion, and an evaluation test plant was developed for a thorough evaluation of the device are discussed.
Author

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**N86-16674#** Welding Inst., Cambridge (England).
**FATIGUE TESTING OF TUBE TO NODE BUTT WELDS ENVISAGED FOR RAE BEDFORD FLIGHT SIMULATOR**
T. D. ROSENBERG Apr. 1985 30 p refs Prepared for Vickers PLC, Hampshire, England
(REPT-23480/2/85; BR95858) Avail: NTIS HC A03/MF A01

Fatigue tests were carried out on tube to node butt welds under axial loads. Results indicate that the joints can be treated as Class F in the BS 5400 fatigue design rules for welded joints. Pressure drop and leak detection systems for crack detection during the operation of the structure were evaluated. The pressure drop system is found to be effective in detecting the presence of through-thickness cracking. The reserve static strength of a joint containing a single through-thickness crack was measured, and found to be equivalent to a nominal stress in excess of the yield strength of the parent material.
Author (ESA)

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**N86-17296#** Kawasaki Heavy Industries, Ltd., Akashi (Japan).
**THE ROLE OF COMPUTATIONAL FLUID DYNAMICS IN AERONAUTICAL ENGINEERING**
T. UCHIDA, T. JYONOUCHI, K. SAWADA, and T. NOHISA *In* National Aerospace Lab. Proceedings of the 2nd NAL Symposium on Aircraft Computational Aerodynamics p 255-270 1984 refs In JAPANESE; ENGLISH summary
(REPT-2) Avail: NTIS HC A14/MF A01

The task of aircraft design often favors a robust, low-cost computational method rather than a sophisticated one. Examples of such engineering methods currently in use are described in this paper. Included are a viscous-inviscid coupling procedure for a 2-D airfoil at high angle of attack in incompressible flow, a vortex-lattice procedure for not-so-slender wings, and extensions of the FLO22 code so as to incorporate the fuselage- and fluid-viscosity effects.
Author

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**N86-17588#** National Aerospace Lab., Amsterdam (Netherlands).
**ACTIVITIES REPORT IN AEROSPACE RESEARCH, WITH DATA CONCERNING THE SCIENTIFIC COMMITTEE NLR-NIVR, INTERNATIONAL COOPERATION CONCERNING AGARD, DNW, GARTEUR AND COOPERATION WITH INDONESIA Annual Report, 1984 [VERSLAG OVER HET JAAR 1984. MET GEGEVENS OMTRENT DE WETENSCHAPPELIJKE COMMISSIE NLR-NIVR, DE INTERNATIONALE SAMENWERKING IN AGARD-, DNW-, ETW- EN GARTEUR-VERBAND, EN OMTRENT DE SAMENWERKING MET INODNESIE]**
1984 145 p refs Partly in DUTCH and ENGLISH Original contains color illustrations
Avail: NTIS HC A07/MF A01

Aerodynamics, flight, structures and materials, space technology and remote sensing, informatics, environment, energy supply, and equipment, were studied. Research for the Fokker-50 and 100 projects and related development of a measuring, recording, and data processing system for aircraft are described. Damage tolerance of aircraft structures and materials such as carbon/epoxy laminates with outer plies of glass, Aramid and carbon fabric, titanium alloys, and carbon fiber composites, were investigated. Fluid physics research, spacecraft attitude control system tests, and thermal vacuum research were carried out. The development of a multispectral CCD scanner, synthetic aperture radar, and side-looking airborne radar, were studied. A program to integrate aerospace informatics disciplines is described. Air traffic noise calculations, and windpower utilization research were executed. A simulation system for the satellite navigation system NAVSAT was developed. A low-speed wind tunnel LST 3x2.25 was commissioned.
Author (ESA)

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**N86-17637#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de la Physique Generale.
**FEASIBILITY STUDY OF A DEVICE TO CONTROL AIRCRAFT ELECTROMAGNETIC PROTECTION [ETUDE DE FAISABILITE D'UN DISPOSITIF DE CONTROLE DES PROTECTIONS ELECTROMAGNETIQUES SUR AERONEFS]**
R. C. DAVIDSON and J. L. BOULAY Mar. 1985 43 p refs In FRENCH
(Contract DRET-83-123)
(ONERA-RS-10/3466-PY) Avail: NTIS HC A03/MF A01

Electromagnetic transparence of aircraft structural elements is discussed. Laboratory measurements and parameters composing a wall transparence coefficient are studied. It is shown that an electric conductivity measurement device could be used to deduce the electromagnetic transmission rate. The device should be developed from the CORAS transducer, which measures high range surface resistivity.
Author (ESA)

**N86-17648#** Joint Publications Research Service, Arlington, Va.
**ESTABLISHMENT AND USE OF TIME UNIFICATION SYSTEM FOR CIVIL AVIATION**
M. M. MALYY *In its* USSR Report: Electronics and Electrical Engineering (JPRS-UEE-84-016) p 30 30 Nov. 1984 Transl. into ENGLISH from Izmeritelnaya Tekhnika (Moscow, USSR), no. 5, May 1984 p 28-30
Avail: NTIS HC A03/MF A01

Precise and fail proof operation of the various services used by civil aviation throughout the territory of the USSR depends largely on synchronization, the latter requiring periodic indication of time scales and involving the concept of time unification. The principal users of a time unification system are the traffic control service and the flight crew. Since 1974 electromechanical hand-and-dial clocks in airports have been gradually replaced with modern signal clocks. Installation of secondary clocks in control towers, time encoding in the secondary clocks, and interfacing the clock room with the computer of the appropriate automatic control system are improvements made in the control tower. Time indicating and time keeping equipment is also installed in airplanes for tie-in with airports by means of radio signals over metric wave or decametric-wave communication channels. The necessary short range radio navigation system with the inclusion of satellites for transmittal of unified time information from airports to airplanes and equipment characterized by satisfactory technical accuracy and high stability with means for automatic or semiautomatic time correction guaranteeing high reliability for a period of 10 years is produced. Author

**N86-17666#** British Aerospace Aircraft Group, Preston (England). Wind Tunnel Dept.
**HOT GAS LABORATORY TWIN NOZZLE CALIBRATION**
A. P. WINSTANLEY 1 Jul. 1985 37 p refs
(BAE-ARG-200) Avail: NTIS HC A03/MF A01

The quality of a twin nozzle flow is investigated. The assembly was manufactured to produce high temperature jet related data relevant to VSTOL aircraft when adapted to a wind tunnel hot gas facility. The twin nozzles are of an Ni-resistant flake cast iron construction whereas the standard 120 mm diameter single nozzle is a stainless steel, water-cooled fabrication. A calibration rake was used to acquire pressure and temperature data over an array of data points. The tests show that the construction method is satisfactory. The total pressure quality in the exit plane is good. A negative temperature gradient is found along the y axis. The nozzle reference pressure is a good indication of the average total pressure in the exit plane. Author (ESA)

**N86-17699#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
**A SURVEY OF NUMERICAL METHODS FOR THE CALCULATION OF INVISCID, POSSIBLY ROTATIONAL EULER FLOWS AROUND AERONAUTICAL CONFIGURATIONS**
J. W. BOERSTOEL 11 Oct. 1983 20 p refs
(NLR-TR-83130-U; B8568392) Avail: NTIS HC A02/MF A01

Numerical methods for the calculation of inviscid Euler flows are reviewed. For aerodynamic applications, the existing methods are accurate and cheap enough. However, shocks and vortex sheets may have to be better modeled to achieve higher numerical accuracy. Computation times can be reduced by applying multigrid methods. Author (ESA)

**N86-17700#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
**BOUNDARY LAYER CALCULATIONS ON THE LEEWARD SURFACE OF A SLENDER DELTA WING AT INCIDENCE**
A. C. DEBRUIN 22 Dec. 1983 41 p refs
(NLR-TR-84001-U; B8569025) Avail: NTIS HC A03/MF A01

A 3D-boundary layer calculation method was used to predict the location of the secondary boundary layer separation on the leeward surface of a slender delta wing at incidence for fully laminar flow and forced boundary layer transition at the 50% semispan location. The behavior of the predicted boundary layer properties is qualitatively in good agreement with the experiment. A difference between the potential flow and experimental pressure distribution causes a discrepancy between the predicted and the experimentally observed location of secondary separation. It is expected that the potential flow pressure distribution can be improved when the leading edge and the secondary separation vortex sheet are correctly modeled in the potential flow calculation method. It is concluded that boundary layer calculations can provide valuable information for the location of the secondary separation line, to model the associated vortex sheet. Author (ESA)

**N86-17702** Royal Aircraft Establishment, Farnborough (England).
**A SMOKE GENERATOR FOR THE ABSOLUTE CALIBRATION OF GAS TURBINE ENGINE SMOKE SAMPLING AND MEASURING SYSTEMS**
S. P. GIRLING and C. D. HURLEY Jan. 1985 27 p refs
(RAE-TM-P-1044; BR95024) Avail: NTIS HC A03/MF A01

A smoke generator capable of producing a stable source of smoke over a prolonged period by pyrolysis of aviation kerosene was developed. The smoke levels and characteristics are representative of aircraft engine smoke. The smoke generator provides a means of assessing and calibrating smoke sampling and measurement systems. Accurate gravimetric calibration of SAE smoke number against carbon loading is described. Author (ESA)

**N86-17726#** Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
**DESCRIPTION OF A NONDESTRUCTIVE FACILITY USING HOLOGRAPHIC INTERFEROMETRY**
P. BARBIER and C. LEFLOCH 1985 6 p Presented at 11th World Conference on Nondestructive Testing, Las Vegas, Nev., 3-8 Nov. 1985
(SNIAS-852-430-105) Avail: NTIS HC A02/MF A01

A holographic interferometry procedure to test aircraft engine use manufactured using composite materials was developed. The equipment includes a laser source, a reading laser, a holographic camera, a chamber in which a depression can be created, and a control panel. The camera is placed inside the structure and revolves through 180 deg to observe the front and rear areas. Photographs of holograms obtained on a sample are presented. A surface of 0.5 sq m may be inspected in 15 min. The economic advantages of the test method are discussed. Author (ESA)

**N86-17774#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
**QUADRINOMIAL DISTRIBUTION FOR THE CHARACTERIZATION OF NONDESTRUCTIVE INSPECTION (NDI) RELIABILITY**
J. H. HEIDA 27 Jun. 1984 17 p refs Presented at 3rd European Conference on Nondestructive Testing, Florence, Italy, 15-18 Oct. 1984
(NLR-MP-84064-U; B8568524) Avail: NTIS HC A02/MF A01

Inclusion of probability of detection (POD) and probability of recognition (POR) of flaws in characterization of nondestructive inspection (NDI) reliability is considered. Possible measures for this characterization are discussed using inspection results of a test specimen population of 200 identical 4340 steel aircraft landing gear components rejected from service because of crack indications or exceedance of the safe service life. It is concluded that it is doubtful whether the discussed parameters give an appropriate measure of NDI reliability; it is recommended to establish minimum values for the POD and POR at a specified confidence level. Author (ESA)

**N86-17808#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**DESIGN OF HAT-STIFFENED COMPOSITE PANELS UNDER UNIAXIAL COMPRESSION AND SHEAR. MINIMUM MASS OPTIMIZATION BASED ON A SIMPLIFIED THEORY**

G. ROMEO (Polytecnico di Torino, Italy) 1984 46 p refs
Sponsored by Technical Hogeschool, Delft
(VTH-LR-312) Avail: NTIS HC A03/MF A01

Literature on stiffened compression panels was reviewed, and a computer program for the evaluation of minimum-mass hat stiffened panels under uniaxial loads was written. In the analytical studies the mechanical properties of the graphite/epoxy material were considered to be linearly elastic and the lower stresses Young's modulus was used. Since a reduction of up to 20% is possible in compression, the 50% mass-saving derived from these results seems too optimistic. A reduced stress-dependent Young's modulus should be used and the tangent modulus theory applied. Better mass-savings are possible with higher hat height values, but these depend on wing airfoil thickness since the optimal distance from the bending neutral axis is required. Under uniaxial compression, a mass-saving up to 40% compared with test data on aluminum panels is evaluated. The fabrication process did not require complex tooling or a difficult production technique. However, complexity could arise for a correct nondestructive inspection of all parts of the panel, because of the closed stiffeners with inclined surfaces. Author (ESA)

**N86-17809#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

**FATIGUE RATED FASTENER SYSTEMS IN ALUMINUM ALLOY STRUCTURAL JOINTS**

H. H. VANDERLINDEN 14 Jul. 1983 29 p refs Presented at 12th ICAF Symposium, Toulouse, France, 25-27 May 1983
Sponsored by Royal Netherlands Air Force Directorate of Material
(Contract NIVR-1892)
(NLR-MP-83045-U; B8569323) Avail: NTIS HC A03/MF A01

A fatigue rated fastener systems test program for aircraft is described. The program assesses fatigue lives of fastener systems in combination with hole preparation techniques using different joint geometries. Establishment of cost figures in relation to the fatigue performance and the development of a reference datum for the comparison of test results produced in different countries are included. For high load transfer single shear joints, joint designs and their double shear equivalent designs are compared. Evaluation includes testing under FALSTAFF loading and the measurement of load transfer and secondary bending using standard procedures. Fatigue test results of low load transfer, medium load transfer 1 1/2 dogbone, and high load transfer double shear specimens are also included. Procedures for measuring load transfer and secondary bending are illustrated using 1 1/2 dogbone specimens. Author (ESA)

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## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-19816*#** San Jose State Univ., Calif.

**AN EXTREME CLEAR AIR TURBULENCE INCIDENCE ASSOCIATED WITH A STRONG DOWNSLOPE WINDSTORM**

P. F. LESTER (San Jose State University, CA) and R. E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 8 p. refs
(AIAA PAPER 86-0329)

The meteorological conditions present during an occurrence of clear-air turbulence (CAT) associated with the presence of a mountain wave are documented. The incident caused severe vertical accelerations of two passenger aircraft travelling at 33,000 ft altitude. Satellite, pilot report and surface and upper air meteorological data were examined to characterize the situation. The CAT was apparently produced by an unusually strong westerly flow over the Rocky Mountains, causing a lee wave over the foothill regions where the turbulence was experienced. A downslope windstorm formed at the same time as wave activity on three scales: 60 nm, 17 nm and 1 nm in the troposphere. The data suggest that surface observations of severe windstorms in the mountain foothill regions could be used to predict the presence of CAT conditions, especially if combined with available data on lee waves. M.S.K.

**A86-20665**

**USING A MENU-BASED NATURAL LANGUAGE INTERFACE TO ASK SPATIAL DATABASE QUERIES**

C. W. THOMPSON (Texas Instruments Central Research Laboratories, Dallas) IN: Spatial information technologies for remote sensing today and tomorrow; Proceedings of the Ninth Pecora Symposium, Sioux Falls, SD, October 2-4, 1984 . Silver Spring, MD, Institute of Electrical and Electronics Engineers, Inc., 1984, p. 95-101. refs

Menu-based natural language understanding has a number of advantages over conventional natural language interface technology. This paper describes the menu-based approach and discusses some extensions to a domain independent interface generator that allows a user to ask spatial database queries. Author

**N86-16749#** Rijksluchtvaartdienst, The Hague (Netherlands).

**REPORT OF THE WORKING GROUP FOR SENSITIVITY ANALYSIS AND ZONING CALCULATIONS (GAZOB) Final Report [EINDRAPPORT VAN DE WERKGROEP GEVOELIGHEIDSANALYSE ZONERINGSBEREKENINGEN (GAZOB)]**

May 1985 91 p refs In DUTCH
Avail: NTIS HC A05/MF A01

The sensitivity of noise pollution calculations to the input data for Schiphol airport was analyzed. Noise pollution calculations for Schiphol airport are reviewed.

**N86-16750#** Rijksluchtvaartdienst, The Hague (Netherlands).

**ANALYSIS AND CONCLUSIONS OF THE WORKING GROUP FOR SENSITIVITY ANALYSIS AND ZONING CALCULATIONS (GAZOB) Final Report**

*In its* Report of the Working Group for Sensitivity Analysis and Zoning Calculations (GAZOB) 42 p May 1985 In DUTCH
Avail: NTIS HC A05/MF A01

The sensitivity of noise pollution calculations to the input data system was analyzed in the area of Schiphol airport with a consideration for housing construction plans, based on the present runway system for the situation expected around 1990 and later. The analysis allows a better insight into the variation of factors which contributes to noise pollution calculations. The only free parameters for the choice of a zone contour are shown to be the fleet composition and the number of aircraft movements. The possible conditions in 1995 and 2000 are calculated and show a substantial noise reduction the planned improvements. It is concluded that a regional zoning for home construction based on the contours calculated for 1990 is justified. Author (ESA)

**N86-16751#** National Aerospace Lab., Amsterdam (Netherlands). Afdeling Vliegtuigen.

**NOISE NUISANCE CALCULATIONS FOR SCHIPHOL AIRPORT ON BEHALF OF THE SENSITIVITY ANALYSIS AND ZONING CALCULATIONS WORKING GROUP (GAZOB) [GELUIDSBELASTINGBEREKENINGEN VOOR DE LUCHTHAVEN SCHIPHOL TBV DE WERKGROEP GAZOB]**

H. J. POUTSMA *In* Rijksluchtvaartdienst Report of the Working Group for Sensitivity Analysis and Zoning Calculations (GAZOB) 48 p May 1985 refs In DUTCH
(Contract RB-RLD-1984/1985:5.2)
(NLR-TR-85034-U) Avail: NTIS HC A05/MF A01

Starting points and results of noise pollution calculations for the Schiphol airport are reviewed. Calculation procedure, aircraft data, runway structure, aircraft motions, and test flights are explained. The results of calculations are presented as noise pollution contours. Author (ESA)

**N86-16757#** Rolls-Royce Ltd., Derby (England). Noise Technology Div.

**AIRCRAFT NOISE CONTROL: PROSPECTS FOR THE 21ST CENTURY**

M. J. T. SMITH 23 Jul. 1985 10 p Presented at 52nd National Society for Clean Air Conference, Scarborough, England, Oct. 1985
(PNR-90272) Avail: NTIS HC A02/MF A01

The background, policies and prediction of the evolution of aircraft noise control technology are discussed. The probable world fleet composition through to the end of the century is analyzed. Domination of turbofan technology is foreseen by 1988. Examples of recent developments are examined for goals on the order of 95 to 100 dB. Author (ESA)

**N86-16843#** National Weather Service, Silver Spring, Md. Techniques Development Lab.

**AFOS (AUTOMATION OF FIELD OPERATIONS AND SERVICES) MONITORY OF TERMINAL FORECASTS**

D. J. VERCELLI and G. A. NORMAN May 1985 33 p
(PB85-236388; NOAA-NWS-TDL-CP-85-1) Avail: NTIS HC A03/MF A01 CSCL 04B

Aviation terminal forecasts (FT's) are issued three or four times per day, depending on location, for selected terminals within the area of responsibility of a Weather Service Forecast Office (WSFO). The FT's contain specific meteorological information on cloud heights and amount, visibility, weather, obstructions to vision, and wind. This information is considered to be the most important to aviation interest in and near the terminal area. A FORmula TRANslation (FORTRAN) program, described by this document, will assist the forecaster with this time-consuming weather-watch function by comparing the information in the FT's with the corresponding information on the surface airways observations. The FT monitoring program, called MONITR makes use of two sets of criteria to determine whether or not a problem exists with a particular FT. In both the amendment and alert cases, the forecaster still has the final responsibility to decide whether or not the FT should be amended. GRA

**N86-16854#** National Weather Service, Garden City, N.Y.

**CERR: AN AVIATION VERIFICATION PROGRAM**

M. R. PEROUTKA Apr. 1985 28 p
(PB85-204824; NOAA-NWS-ERCP-30) Avail: NTIS HC A03/MF A01 CSCL 04B

Aviation verification statistics have been computed for Cleveland forecasters since 1980. For most of these years, the computations were done by hand, and a simple statistic had to be developed. The CERR program was developed soon after the National Verification Programs began to run, and it has replaced all the manual computations. The statistic chosen for verification was the average MOS category error. This statistic is simply the absolute value of the difference between the category forecast and the category observed. Scores are computed for each forecaster and guidance at each station for each period forecast. The percent improvement over guidance is also computed. GRA

**N86-17816*#** Arizona Univ., Tucson. Optical Sciences Center.

**SPECTRORADIOMETRIC CALIBRATION OF THE THEMATIC MAPPER AND MULTISPECTRAL SCANNER SYSTEM Quarterly Report, 1 Jun. - 31 Aug. 1985**

P. N. SLATER and J. M. PALMER, Principal Investigators 30 Sep. 1985 18 p ERTS
(Contract NAS5-27832)
(E86-10022; NASA-CR-175861; NAS 1.26:175861; QR-11) Avail: NTIS HC A02/MF A01 CSCL 08B

The eleventh quarterly report on Spectroradiometric Calibration of the Thematic Mapper (Contract NAS5-27832) discusses calibrations made at White Sands on 24 May 1985. An attempt is made to standardize test results. Critical values used in the final steps of the data reduction and the comparison of the results of the pre-flight and internal calibration (IC) data are summarized. F.M.R.

**N86-17915#** National Aerospace Lab., Amsterdam (Netherlands). Afd. Vliegtuigen.

**NOISE ASSESSMENT AROUND SCHIPHOL AIRPORT (THE NETHERLANDS) IN 1981 [DE GELUIDSBELASTING ROND SCHIPHOL IN 1981]**

J. F. W. BAARSLAG 4 May 1982 24 p refs In DUTCH
(Contract RB-RLD-82-4.1)
(NLR-TR-82034-U) Avail: NTIS HC A02/MF A01

Aircraft noise assessment calculations around an airport are presented. Airport and surroundings are projected on a flat reference surface, on which a 100 m mesh network of points is superimposed. Minimum distances between flight paths and points, maximum noise levels of aircraft per category, and lateral correction factors are determined. Using these data, the number of flight motions, and night penalty factors of aircraft per category, the noise assessment is calculated in cost units with a logarithmic aircraft noise pollution formula. Interpolating between points of equal assessment, noise assessment contours, and areas within are mapped. Author (ESA)

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## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-19302**

**COMPUTER TOOLS AND TECHNIQUES FOR ANALYSIS OF DISCRETE DATA FROM AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES)**

J. D. FRITSVOLD and J. E. VETTER (U.S. Navy, Analytical Systems Div., Washington, DC) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 37-40. refs

Analyses have been conducted for automated aircrew escape systems, using statistical models generated in part by computer tools to study the significant factors that contribute to problems during ejections or emergency escapes. Extensive use is made in this work of discrete variables that are presented in a frequency table of cross classifications. Significant associations are thereby established, while spurious ones are rejected. The computational capability in question allows the study of the effects of several factors simultaneously on a variable of interest, such as the likelihood of a severe injury or fatality during an aviation emergency. O.C.

**A86-19309**

### U.S. NAVY ALSS CORPORATE REPORT 1984

E. P. VOLLMER (US. Naval Air Systems Command, Washington, DC) and D. N. DESIMONE (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 71-74.

This paper provides an overview of the Navy's Aviation Life Support Systems (ALSS) programs that have entered or completed engineering development. The various development programs show a continued emphasis on escape systems and anti-exposure clothing and equipment and a relatively new development focal point, CBR defense. Additional subject areas addressed include oxygen systems, restraint systems, parachutes and flotation equipment. The current status for each program is detailed, along with planned near-term efforts and, where available, projected contractual efforts. Author

**A86-19310**

### HOW MUCH INHERENT BUOYANCY IS ACCEPTABLE IN A HELICOPTER PASSENGER IMMERSION SUIT

C. J. BROOKS and J. D. M. PROVENCHER IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 75, 76. refs

The buoyancy value of helicopter crewmembers' immersion suits (for hypothermia protection) may be so high as to actually prevent escape from an immersed helicopter's inverted cabin. A recent evaluation of quick-down immersion suits noted a wide range of inherent buoyancies. Attention is presently given to the tradeoffs between inherent buoyancy, hypothermia protection, and underwater escape capability. A 20-lb inherent buoyancy figure is recommended. O.C.

**A86-19329**

### LIMB RESTRAINT EVALUATOR (LRE)

T. GUSTIN (Systems Research Laboratories, Inc., Dayton, OH) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 183-187. USAF-supported research.

The present paper provides a description of a state-of-art data acquisition and recording system which is part of an advanced ejection system test manikin developed by an American company. The manikin is the Limb Restraint Evaluator (LRE), which was designed to test restraint devices to be incorporated into modern aircraft ejection equipment by the U.S. Air Force. The design goals of the LRE are considered, taking into account the successful sensing and capturing of data for 96 phenomena sources for a free-flight test article for the ACES II restraint tests. Difficulties related to the extremely large number of data channels were overcome by employing a Pulse Code Modulation (PCM) type system (time multiplexed). Attention is also given to the use of a low pass filter, a challenge related to telemetry dropout, the selection of onboard storage technique, and the CPU. G.R.

**A86-19333**

### THE EFFECT OF WATER INGRESS ON BUOYANCY AND THERMAL QUALITY OF SURVIVAL SUITS

A. PASCHE (Norwegian Underwater Technology Centre, Laksevas, Norway) and R. ILMARINEN (Institute of Occupational Health, Helsinki, Finland) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 204-207. Research supported by Statoil. refs

Several survival suits have been tested regarding water leakage in the suit during evacuation from a sinking and turned helicopter, total buoyancy for a person dressed in a suit, and the suits insulating properties after evacuation from the helicopter. Water content in the suit followed an evacuation with partly open zippers would be in order of 9-18 kg. Closed-off air in the suit could give some suits a buoyancy in a turned helicopter as high as 40-50 kg. Water leakage into the suits, which is likely to occur, would change the thermal insulation properties of the suits. Even smaller water ingress would have considerably effect on body cooling, while water ingress in a magnitude as established for the evacuation situation result in a very rapid drop in core temperature of the subject (2.0-2.5 C/hour). Author

**A86-19336**

### PROTECTIVE RESPIRATOR FOR THE AAH-64 ADVANCED ATTACK HELICOPTER

D. M. ENGLISH (U.S. Army, Chemical Research and Development Center, Aberdeen Proving Ground, MD) and L. DICKERSON (ILC Industries, Inc., Frederica, DE) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 223-226. Army-supported research.

The present paper is concerned with the background and development philosophy utilized in designing and fabricating a protecting mask system for the U.S. Army AH-64 Attack Helicopter. The very sophisticated weapons and flight systems employed by this helicopter require close optical coupling to various devices. For this reason, current protective masks cannot be used effectively. The U.S. Army issued, therefore, a contract for the development of a protective mask which would interface with the AH-64 Integrated Helmet and Display Sighting System (IHADSS). Attention is given to a description of the AH-64 helicopter, the operational capabilities of the AH-64, mask system requirements, a mask system description, a blower system description, and a program overview. An accelerated development of the IHADSS mask system will allow the U.S. Army to field the AH-64 helicopter on schedule. G.R.

**A86-19343**

### PILOT UNDERWATER HIGH PRESSURE EMERGENCY BREATHING SYSTEM

M. RATAJCZAK (Moog, Inc., East Aurora, NY) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 259-262.

The High Pressure Emergency Breathing System (HPEBS) has the objective to provide life support for an aircrewman in the event of a parachute landing over water. A water activated switch closes the antisuffocation valve in the breathing system, and the HPEBS is actuated. A utilization of the HPEBS increases survival possibilities for an aircrewman in a high sea state. The HPEBS is to provide 500 standard liters of air for consumption. The air is stored in a high pressure spherical vessel. A pyrotechnic actuator and a pressure reducer is also provided. Attention is given to details of pressure vessel design, the pyrotechnic squib, aspects of pressure reducer design, and acceptance level test results. G.R.

**A86-19344**

### LABORATORY AND FLIGHT TESTING OF BALLISTIC PROTECTIVE HEADGEAR FOR ROTARY WING AIRCREW

D. S. MCCAULEY (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 263-268. refs

The results of laboratory and flight tests on two types of ballistic protective gear developed for helicopter aircrew that can be exposed to small arms fire and fragments are reported. The type 1 system is a complete ballistic protective helmet assembly, while the type 2 system consists of a ballistic clip-on unit which can be quickly added to a lightweight, form-fitting helmet. Both systems were shown to meet the ballistic requirements, when tested in accordance with standard requirements of an average ballistic limit, V50, of 1150 ft/s for a 17 grain, 0.22 caliber, type 2 fragment-simulating projectile, and demonstrated good impact resistance. Although most subjects in the flight tests preferred the clip-on system because of weight considerations, the ANVIS ready helmets available to almost all battlefield aircrew are not compatible with a ballistic clip-on bonnet. Therefore, further development of the type 1 system only is recommended. I.S.

**A86-19345**

### THE STATE OF THE ART OF ANTHROPOMORPHIC MANIKINS AND REQUIREMENTS FOR THE EVALUATION OF ADVANCED AIRCRAFT EJECTION SYSTEMS

J. A. TIEBER (Systems Research Laboratories, Inc., Dayton, OH) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 269-275.

A study was conducted to define the capabilities of existing anthropomorphic manikins and the capabilities required of modern manikins to be suitable for the evalution of advanced aircraft escape systems. Specifications for an advanced ejection system test manikin, which resemble and act like a human body when subjected to aerodynamic and inertial loadings associated with aircraft escape conditions, include the simulation of human response to force loadings at various body components, anthropometric accuracy, mass and inertial properties of various body segments, joint articulation, and structural strength. Data acquisition considerations include the type and placement of sensors, number of data channels, data processing and formatting, and on-board storage and/or telemetry requirements. The standard packaging, placement, and environmental protection factors also must be considered. The development of a family of manikins, consisting of an average member and two members representing the fifth and 95th percentiles of the anthropometric spectrum, is recommended. I.S.

**A86-19351**

### EVALUATION OF PILOT PERFORMANCE AND AIRCREW PROTECTIVE DEVICES IN A SIMULATED F-14 FLAT SPIN ENVIRONMENT

J. EYTH, JR. and D. P. GLEISNER (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 22nd, Las Vegas, NV, December 9-13, 1984, Proceedings . Van Nuys, CA, SAFE Association, 1985, p. 350-355. refs

A pilot's response to a simulated F-14 flat spin is studied. The F-14 aerodynamic model and the human centrifuge motion platform of the Dynamic Flight Simulator are examined. A spin recovery test is performed to evaluate a pilot's ability to recover the aircraft from the spin and determine what factors influence an unsuccessful recovery. The spin warning display system and restraint system evaluated in the spin test are described. Graphs are provided on the number of revolutions, altitude loss, and recovery time as a function of spin entry condition. The results reveal that higher yaw rates cause an increase in the numbar of revolution, greater altitude loss prior to recovery of the aircraft, and the pilots are not incapacitated by the high -Gx forces. The spin warning display and restraint systems are highly rated by the pilots. I.F.

**A86-22023#**

### USAF TOXICOLOGY RESEARCH ON PETROLEUM AND SHALE-DERIVED AVIATION GAS TURBINE FUELS

J. A. MARTONE (USAF, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 4 p. refs

(Contract F33615-80-C-0512)

(ASME PAPER 85-GT-34)

The effect of exposure to the hydrocarbons of aircraft turbine fuels on man is examined. Methods used to establish chemical exposure limits, which include the Threshold Limit Value-Time-Weighted Average (TVL-TWA), TVL-Short-term Exposure Limit (TVL-STEL), and skin notation, are described. The proposed limits for JP-4 are a TLV of 700 mg/cu m, a STEL of 1050 mg/cu m, and n-hexane as a skin notation. Experiments are conducted in which rats are exposed to 2500 and 5000 mg/cu m of JP-4 for 8 months, and 500 and 100 mg/cu m for 90 days. The 8-month data reveal no effect on the rats by the fuel is detected; however, in the 90-day test group reduced weight gain, the formation of hyaline droplets in the proximal tubular epithelium, increased kidney/body weight ratios, and renal carcenoma are observed. The mechanism which causes this hydrocarbon-induced renal effect and its possible influence on man are being investigated. I.F.

**A86-22626**

### A NEW APPLICATION OF ADAPTIVE NOISE CANCELLATION

W. A. HARRISON (Sanders Associates, Inc., Nashua, NH), J. S. LIM (MIT, Cambridge, MA), and E. SINGER (MIT, Lexington, MA) IEEE Transactions on Acoustics, Speech, and Signal Processing (ISSN 0096-3518), vol. ASSP-34, Feb. 1986, p. 21-27. Research sponsored by Sanders Associates, Inc. refs

(Contract NR PROJECT 049-506; N00014-81-K-0742; F19628-85-K-0028; NSF ECS-80-07102)

Widrow et al's (1975) adaptive noise cancellation (ANC) method is applied to the case where an acoustic barrier exists between the primary and reference microphones. ANC, by updating the coefficients of the noise estimation filter only during silence, can furnish substantial noise reduction with little speech distortion even when the acoustic barrier provides only moderate attenuation of acoustic signals. An evaluation is made of a modification of ANC for the oxygen facemasks worn by fighter pilots; if a noise field is created using a single source, an 11-dB SNR improvement is achieved by attaching a reference microphone to mask's exterior. O.C.

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## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-19608**

### UPSILON INVARIANTS - A UNIFORM SET OF MOMENT INVARIANTS

V. N. DVORNYCHENKO (Northrop Corp., Electro-Mechanical Div., Anaheim, CA) IN: Applications of digital image processing VII; Proceedings of the Meeting, San Diego, CA, August 21-24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 40-46. refs

A set of uniform magnitude, minimal-order moment invariants is introduced. The relationship to the Hu and other invariants is explained. It is shown how the present invariants circumvent some of the more serious limitations of the Hu set. For example, it is shown that the Hu invariants are algebraically dependent and how this arises. Graphic representations in the form of hidden-line surfaces in feature space are presented. A proposed basis for 'aspect-independents' is outlined. Author

**A86-19821#**

### CONTROL METHODOLOGY FOR STOCHASTIC SYSTEM CHARACTERISTICS MODULATION

M. N. WAGDI (Suez Canal University, Port Fouad, Egyt) and A. A. ABDEL KADER (Arab Organization for Industrialization, Cairo, Egypt) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs

(AIAA PAPER 86-0335)

A new control methodology for modulation of stochastic system characteristics is presented. Two realistic concepts are introduced. The stochastic behavior of each individual system parameter is considered. This is done by superposing a stochastic part through a small perturbation factor to the nominal deterministic part for each system parameter. The other realistic concept is that of considering the combined dynamics of both plant and actuators. A direct relation between the control gain matrix and the closed loop eigenvalues is derived. A criterion is obtained to insure the control system robustness. The present methodology is applied to the design of a lateral controller for a typical high performance fighter aircraft. Author

**A86-19865#**

**THE ADAPTIVE MANEUVERING LOGIC PROGRAM IN SUPPORT OF THE PILOT'S ASSOCIATE PROGRAM - A HEURISTIC APPROACH TO MISSILE EVASION**

G. H. BURGIN, W. H. WILLIAMS, and L. B. SIDOR (Titan Systems, Inc., San Diego, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(AIAA PAPER 86-0423)

A real time man-in-the-loop missile evasion simulation is conducted for a fighter aircraft, using a pilot's associate program designated 'Adaptive Maneuvering Logic' (AML) to determine suitable maneuvers on the basis of a set of production rules. In one of the two operating modes of the AML, maneuvering cues are displayed on the pilot's HUD. In the second mode, the AML-generated maneuver commands are fed directly into the flight control system. An illustrative two-missile evasion is presented. O.C.

**A86-20518**

**COMPARISON OF PERFORMANCE CHARACTERISTICS OF DDC ALGORITHMS IMPLEMENTED ON A MICROPROCESSOR**

M. R. PATEL and G. COOK (Vanderbilt University, Nashville, TN) IN: SOUTHEASTCON '84; Proceedings of the Conference, Louisville, KY, April 8-11, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 389-393. refs

This paper presents the study of various digital control strategies, proportional-integral-derivative, deadbeat, and discrete time optimal linear regulator, implemented on a Motorola MC6801 microprocessor and applied to the pitch control of an aircraft. Testing and evaluation was carried out by simulating the aircraft on an analog computer. The digital algorithms performed quite well and the use of the MC6801 microprocessor demonstrated the ease and efficiency with which a digital controller can be realized. Author

**A86-20667**

**UNDERSTANDING NATURAL LANGUAGE COMMANDS**

H. H. CHIN (Grumman Aerospace Corp., Bethpage, NY) IN: Spatial information technologies for remote sensing today and tomorrow; Proceedings of the Ninth Pecora Symposium, Sioux Falls, SD, October 2-4, 1984 . Silver Spring, MD, Institute of Electrical and Electronics Engineers, Inc., 1984, p. 106-119. refs

A tunable frame-grammar currently being developed for a Natural Language Control parser is described. How attributes to words and phrases are fitted in the frame structure, and how a pragmatic component helps the parser to choose among competing sentential actions in order to interpret commands correctly, are shown. A pragmatic component which describes the sensibility of a command text in the understanding process is developed. One set of pragmatic rules is used to check the temporal and spatial reasoning of actions, and another set is used to check the state and cause reasoning about goals. Two kinds of ambiguity in the pragmatics are explored in detail. C.D.

**A86-22305#**

**MULTI-KNOT BOOLEAN SUM INTERPOLATING SURFACE INTERACTIVE DESIGN OF AIRCRAFT CONFIGURATION**

M. GAO Northwestern Polytechnical University, Journal, vol. 3, Oct. 1985, p. 487-498. In Chinese, with abstract in English. refs

A new kind of modelling tool, a multiknot-based Boolean sum surface, is proposed. Using different Boolean sum operators, more than thirty surface schemes are derived, and the programs of the surfaces are developed for the interactive design of aircraft configuration with computer graphics. The surface interpolating methods are applied to define components of two types of aircraft under development. It is found that they can save as much as 40 percent CPU time compared with B-spline fitting surface. The interactive adjustment of knot parameters is predictable and simple. C.D.

**A86-22306#**

**RECURSIVE INSTRUMENTAL VARIABLE ALGORITHMS FOR MODAL PARAMETER ESTIMATION OF STRUCTURAL SYSTEM**

Z. LI, X. LIU, and Y. ZHU Northwestern Polytechnical University, Journal, vol. 3, Oct. 1985, p. 505-514. In Chinese, with abstract in English. refs

In this paper, the Autoregressive Moving Average Exogenous Variables model is constructed for a structural system, and identification techniques called Recursive Instrumental Variable (RIV) methods are used to estimate modal parameters. The methods have good asymptotic properties and are computationally more efficient. They are accurate in the presence of correlated noise and constitute an adaptive processing technique when the noise statistics are not known a priori. A DDF-RIV method which applies RIV techniques to direct decimated data is proposed as a method which efficiently improves the resolution. The performance of the algorithm is illustrated with simulation results, and a vibration test of a one-quarter scale model of a cantilever aircraft wing is used to show the availability of the method. A comparison is made between different RIV, recursive least squares, and frequency domain methods, the results showing that RIV and DDF-RIV methods have some advantages for modal parameter estimation in certain cases. C.D.

**A86-22398**

**SUPPORT EFFECTIVENESS EVALUATION MODEL**

N. N. CHANG and J. E. HOWARD (Northrop Corp., Hawthorne, CA) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 322-328.

The present paper provides the description of a model which was designed to evaluate operating and support alternatives in conjunction with the reliability and maintainability characteristics of fighter aircraft operating in the West European Theater. The model is generic in the sense that neither a prescribed air base structure nor a specific type of aircraft is implied. It is the model's objective to evaluate alternate air-base structure according to the criteria of sortie generation, effectiveness, and resource consumption. Both destruction and creation of new operating locations are simulated. Attention is given to hardware and information flows, the operating location data base, a repair capability sensitivity analysis, and model resource requirements. G.R.

**N86-16944*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DEVELOPMENT OF A KNOWLEDGE ACQUISITION TOOL FOR AN EXPERT SYSTEM FLIGHT STATUS MONITOR**

J. D. DISBROW (Systems Control Technology, Inc.), E. L. DUKE, and V. A. REGENIE Jan. 1986 12 p refs Presented at the AIAA 24th Aerospace Sciences Meeting, Reno, Nev., 6-9 Jan. 1986

(NASA-TM-86802; H-1332; NAS 1.15:86802; AIAA-86-0240)

Avail: NTIS HC A02/MF A01 Palo Alto, Calif.) CSCL 09B

Two of the main issues in artificial intelligence today are knowledge acquisition dion and knowledge representation. The Dryden Flight Research Facility of NASA's Ames Research Center is presently involved in the design and implementation of an expert system flight status monitor that will provide expertise and knowledge to aid the flight systems engineer in monitoring today's advanced high-performance aircraft. The flight status monitor can be divided into two sections: the expert system itself and the knowledge acquisition tool. The knowledge acquisition tool, the means it uses to extract knowledge from the domain expert, and how that knowledge is represented for computer use is discussed. An actual aircraft system has been codified by this tool with great success. Future real-time use of the expert system has been facilitated by using the knowledge acquisition tool to easily generate a logically consistent and complete knowledge base. Author

**N86-16989#** European Space Agency, Paris (France).
**MAXIMUM-LIKELIHOOD ESTIMATION OF PARAMETERS IN LINEAR SYSTEMS FROM FLIGHT TEST DATA. A FORTRAN PROGRAM**
E. PLAETSCHKE and D. B. MACKIE Jun. 1985 94 p refs
Transl. into ENGLISH of "Maximum-likelihood-Schaetzung von Parametern linearer Systeme aus Flugversuchsdaten - ein FORTRAN-Program" Report DFVLR-Mitt-84-10, Brunswick, West Germany, 1984 Original report in GERMAN previously announced as N85-14588
(ESA-TT-896; DFVLR-MITT-84-10) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne DM 31

A program for the maximum-likelihood estimation of aerodynamic parameters in linear systems was developed. The mathematical background is outlined. A list of the input data and the flow charts of the main program and the maximum-likelihood subroutine are presented. Practical handling of the program and its options is demonstrated on two examples. The complete main program and comment listings of the subroutines are given.
Author (ESA)

**N86-17007#** Oxford Univ. (England). Dept. of Engineering Science.
**MULTIVARIABLE CONTROL**
I. POSTLETHWAITE 1985 22 p refs
(OUEL-1589/85) Avail: NTIS HC A02/MF A01

Multivariable control is introduced with an example (a helicopter model) to illustrate what is meant by a multivariable system and how such systems are modeled. The primary objectives of control and the feedback configurations which can be used to achieve them are discussed. Analysis techniques for assessing the significant properties of a control system design are summarized. Design methods for multivariable systems, and implications of digitally implemented controllers are reviewed. Author (ESA)

**N86-17014*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**A SIMULATION OF ROTOR-STATOR INTERACTION USING THE EULER EQUATIONS AND PATCHED GRIDS**
M. M. RAI (Informatics General Corp.) Dec. 1985 10 p refs
(NASA-TM-86821; A-85376; NAS 1.15:86821) Avail: NTIS HC A02/MF A01 CSCL 12A

An unsteady Euler code to study rotor-stator interaction problem was developed. The code uses patched grids that move relative to each other to simulate the motion of the rotor airfoils with respect to the stator airfoils. The Osher integration scheme is used in conjunction with an implicit relaxation approach. The scheme is second order accurate in space and time, and is also TVD in each spatial direction. The numerical results were found to be periodic in time, thus demonstrating the capability of the integration and zonal schemes in simulating periodic time dependent flow. The pressure contours obtained are almost oscillation free because of the TVD nature of the scheme. A new procedure was developed to simulate flows about bodies that move relative to each other. This capability should prove to be very useful in the areas of rotor-stator interaction, propeller-nacelle interaction, and helicopter rotor-fuselage interaction. Author

**N86-17046#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
**MARKOV JUMP-DIFFUSSION MODELS AND DECISION-MAKING FREE FILTERING**
H. A. P. BLOM 24 Oct. 1983 22 p refs Presented at 6th International Conference on Analysis and Optimization of Systems, Nice, France, 19-22 Jun. 1984
(NLR-MP-83067-U; B8566529) Avail: NTIS HC A02/MF A01

Nonlinear filtering of Gaussian observations of a Markov jump-diffusion with an embedded Markov chain, that is described by Poisson measure is considered. The modeling potential of this class of Markov processes is illustrated by simple realistic examples. For the evolution of the conditional expectation of the Markov process, decomposed representations are given. They are used as a basis to obtain approximate filtering algorithms free of decision making mechanisms. The algorithms are discussed for the examples given. Author (ESA)

**N86-18030#** National Aerospace Lab., Amsterdam (Netherlands). Hoofdafd. Informatica/Vliegtuigen.
**COMPUTER AIDED DESIGN (CAD) AT THE NATIONAL AEROSPACE LABORATORY (NETHERLANDS) WITH THE ACCENT ON AIRCRAFT FLIGHT CONTROL SYSTEMS**
W. LOEVE and P. J. VANDERGEEST 24 Mar. 1983 41 p refs In DUTCH; ENGLISH summary Presented at Colloquium Meten en Regelen, Eindhoven, Netherlands, 13 Apr. 1984
(NLR-MP-84032-U; B8568090) Avail: NTIS HC A03/MF A01

The consequences of the integration of CAD-systems within the aircraft industry's infrastructure for information processing and organizational control are elucidated. The possibility to generate the required input for the systems and the usefulness of the output for the design process and ensuing activities are emphasized. It is shown that technical developments with respect to stability and control of aircraft result in the integration of control-technical aspects, alongside those of aerodynamics and structures, within the design process. The development of the tools for designing stability and control systems as part of this integration is described. Author (ESA)

**N86-18056#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
**AN EFFICIENT FILTER FOR ABRUPTLY CHANGING SYSTEMS**
H. A. P. BLOM 25 Jul. 1984 7 p refs Presented at 23rd IEEE Conference on Decision and Control, Las Vegas, Nev., 12-14 Dec. 1984
(NLR-MP-84071-U; B8568106) Avail: NTIS HC A02/MF A01

For a linear discrete time system with coefficients that are governed by an N-state Markov chain, e.g., an aircraft tracked by surveillance radar, a filtering algorithm is defined. It consists of a bank of N interacting Kalman-like filters which communicate with a filter for the Markov chain. When the transition probabilities of the Markov chain are zero, the interacting multiple model (IMM) algorithm reduces to the MM algorithm. Qualitative comparisons with the best other algorithms show an improvement of the ratio between performance and computational complexity up to a factor N. The performance of the IMM algorithm reaches, for small time lags, that of an N times more complex generalized pseudo Bayes algorithm. Author (ESA)

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## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-19790*#** United Technologies Research Center, East Hartford, Conn.
**ISOLATED AND INTERACTING ROUND PARALLEL HEATED JETS**
J. C. SIMONICH (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. Research supported by the United Technologies Corp. refs
(Contract NAS1-16689)
(AIAA PAPER 86-0281)

An experimental study of the flowfield of heated and unheated single and dual jet configurations was performed. This study of two parallel jets is unique since most previous aerodynamic structure experiments were limited to single round and two-dimensional jets. The present closely spaced dual jet geometry was motivated by the potential jet noise reduction available from this configuration. This geometry has shown promise as a method for redirecting jet noise away from ground based observers in side by side or over/under turbofan engine mountings on aircraft (Simonich et al., 1984). Since the effectiveness of this noise reduction technique is based on the existence of two independent jets, an understanding of the aerodynamics of the merging process is essential to establishing the acoustic benefits. The experimental program was structured so that Mach number, jet exit temperature, and spacing to diameter ratios could be independently varied to isolate each effect. Author

**A86-20364*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**THE EFFECT OF ACOUSTIC REFLECTIONS ON COMBUSTOR NOISE MEASUREMENTS**
R. G. HUFF (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Jan.-Feb. 1986, p. 18-24. Previously cited in issue 05, p. 640, Accession no. A85-16103. refs

**A86-20795*** Missouri Univ., Rolla.
**A NUMERICAL MODEL OF ACOUSTIC CHOKING. II - SHOCKED SOLUTIONS**
N. J. WALKINGTON and W. EVERSMAN (Missouri-Rolla, University, Rolla) Journal of Sound and Vibration (ISSN 0022-460X), vol. 104, Jan. 8, 1986, p. 81-107. refs
(Contract NSG-3231)

The one dimensional equations of gas dynamics are used to model subsonic acoustic choking. This model can accommodate non-linear distortion of waves and the eventual formation of shock waves. Several finite differencing schemes are adapted to obtain solutions. The results obtained with the various schemes are compared with the asymptotic results available. The results suggest that no one finite differencing scheme gives solutions significantly better than the others and that most of the difference solutions are close to the asymptotic results. If the acoustic shock wave is sufficiently strong it almost annihilates the acoustic wave; in this situation numerical errors may dominate the results. Such solutions involve very large acoustic attenuations. Author

**A86-22699*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SCALING OF HELICOPTER MAIN ROTOR NOISE IN HOVER**
C. KITAPLIOGLU (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 15 p. refs
(AIAA PAPER 86-0393)

A 2.1-m-diam, one-sixth-scale model helicopter main rotor was tested in hover at the NASA Ames Outdoor Aerodynamic Research Facility. It had previously been tested in hover in the NASA Ames 40- by 80-Foot Wind Tunnel test section. The primary objective of the tests was to obtain acoustic and performance data on a medium-scale rotor at various thrust coefficients and tip Mach numbers to compare to similar existing data on a full-scale helicopter main rotor. Information is presented on the effects of thrust- and tip-speed variation, the effects of boundary-layer trip strips, and the effects of wind conditions. In addition, a preliminary evaluation of the scaling of helicopter main-rotor noise in hover is presented. A secondary objective was to contribute to a data base that will permit the estimation of facility effects on acoustic testing. Author

**N86-17076#** Committee on Science and Technology (U. S. House).
**NOISE REDUCTION TECHNOLOGY**
Washington GPO 1985 135 p Hearing before the Subcommittee on Transportation, Aviation and Materials of the Committee on Science and Technology, 99th Congr., 1st Sess., no. 16, 1 Apr. 1985
(GPO-48-026) Avail: Subcommittee on Transportation, Aviation and Materials

A congressional hearing was conducted and expert testimony heard concerning noise reduction technology as it applied to airports. G.L.C.

**N86-17077*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**COMPARISON OF ADVANCED TURBOPROP AND CONVENTIONAL JET AND PROPELLER AIRCRAFT FLYOVER NOISE ANNOYANCE: PRELIMINARY RESULTS**
D. A. MCCURDY Nov. 1985 30 p refs Presented at the 110th Acoustical Society American Conference, Nashville, Tenn., 4-8 Nov. 1985
(NASA-TM-87637; NAS 1.15:87637) Avail: NTIS HC A03/MF A01 CSCL 20A

A laboratory experiment was conducted to compare the flyover noise annoyance of proposed advanced turboprop aircraft with that of conventional turboprop and jet aircraft. The effects of fundamental frequency and tone-to-broadband noise ratio on advanced turboprop annoyance were also examined. A computer synthesis system is used to generate 18 realistic, time varying simulations of propeller aircraft takeoff noise in which the harmonic content is systematically varied to represent the factorial combinations of six fundamental frequencies ranging from 67.5 Hz to 292.5 Hz and three tone-to-broadband noise ratios of 0, 15, and 30 dB. These advanced turboprop simulations along with recordings of five conventional turboprop takeoffs and five conventional jet takeoffs are presented at D-weighted sound pressure levels of 70, 80, and 90 dB to 32 subjects in an anechoic chamber. Analyses of the subjects' annoyance judgments compare the three categories of aircraft and examine the effects of the differences in harmonic content among the advanced turboprop noises. The annoyance prediction ability of various noise measurement procedures and corrections is also examined. Author

**N86-17081#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
**AEROACOUSTIC RESEARCH IN THE NETHERLANDS RELATED TO AIRCRAFT DEVELOPMENT**
W. B. DEWOLF and S. L. SARIN 25 May 1985 11 p refs Presented at 14th ICAS Congr., Toulouse, France, 9-14 Sept. 1984 Sponsored by Netherlands Agency for Aerospace Programs
(NLR-MP-84049-U; B8568094; ICAS-84-5.8.2) Avail: NTIS HC A02/MF A01

For jet noise reduction the feasibility of a lined ejector nozzle for the Fokker F28 aircraft was investigated by scale model measurements using decomposed hydrogen peroxide for hot jet simulation. Thrust performance measurements were included. For the design of optimum acoustic liners a mathematical model was developed to represent the fan and engine duct acoustically, taking into account the sound generation by rotor wake/stator interaction. Acoustic measurements were performed in the engine inlet of a Fokker F28 aircraft during flight. Techniques and facilities were developed for accurate in-situ measurements of the impedance of acoustic liner materials under realistic conditions. The technique was also demonstrated in-flight. Large reductions of the propeller noise level inside the cabin of the Fokker F27 aircraft were obtained by dynamic vibration absorbers on the fuselage wall structure. Author (ESA)

**N86-18121*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**SEPARATION OF AIRBORNE AND STRUCTUREBORNE NOISE RADIATED BY PLATES CONSTRUCTED OF CONVENTIONAL AND COMPOSITE MATERIALS WITH APPLICATIONS FOR PREDICTION OF INTERIOR NOISE PATHS IN PROPELLER DRIVEN AIRCRAFT Ph.D. Thesis**
M. C. MCGARY Jan. 1986 313 p refs
(NASA-TM-87414; NAS 1.15:87414) Avail: NTIS HC A14/MF A01 CSCL 20A

The anticipated application of advanced turboprop propulsion systems and use of composite materials in primary structure is expected to increase the interior noise of future aircraft to unacceptability high levels. The absence of technically and economically feasible noise source-path diagnostic tools has been a primer obstacle in the development of efficient noise control treatments for propeller driven aircraft. A new diagnostic method which permits the separation and prediction of the fully coherent airborne and structureborne components of the sound radiated by plates or thin shells has been developed. Analytical and experimental studies of the proposed method were performed on plates constructed of both conventional and composite materials. The results of the study indicate that the proposed method can be applied to a variety of aircraft materials, could be used in flight, and has fewer encumbrances than the other diagnostic tools currently available. The study has also revealed that the noise radiation of vibrating plates in the low frequency regime due to combined airborne and structureborne inputs possesses a strong synergistic nature. The large influence of the interaction between the airborne and structureborne terms has been hitherto ignored by researchers of aircraft interior noise problems. Author

**N86-18129#** Metraflu, Ecully (France).
**ANALYSIS OF THE NOISE EMITTED BY A TAIL ROTOR Final Report [ANALYSE DU BRUIT EMIS PAR UN FENESTRON]**
M. ROGER, F. FOURNIER, and P. BECKER 11 Jun. 1985 102 p refs In FRENCH
(Contract DRET-83-025)
Avail: NTIS HC A06/MF A01

A two pole tail rotor noise computation method was developed, and an experimental study of diffracting effects on the turbulence generated by the rotor was carried out. The computation predicts the noise spectra of the tail rotor. The parametric study shows that the varying properties of the incident turbulence can give different spectra. The structure design can attenuate noise by up to 20 to 30 dB. Author (ESA)

**N86-18130#** Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).
**SOUND EXCITATION DURING VORTEX-AIRFOIL INTERACTION**
R. TIMM 1985 120 p refs In GERMAN; ENGLISH summary
(MPIS-MITT-80; ISSN-0374-1257) Avail: NTIS HC A06/MF A01

Two-dimensional vortex-airfoil interaction was investigated in experiments and compared with a theoretical model. In a wind tunnel a cylinder generates a Karman vortex street and in a shock tube an asymmetric airfoil generates a starting vortex. Downstream of these vortex generators an airfoil is located. The influence of the vortices on the airfoil flow was investigated by an interferometer. Strong pressure waves originate from the leading edge of the airfoil. The order of magnitude of their amplitude and directional characteristic are experimentally determined. The experimental vortex paths can neither be correctly predicted by the developed model nor by an existing theoretical potential model.
Author (ESA)

**N86-18131#** Institute for Perception RVO-TNO, Soesterberg (Netherlands). Audiology Group.
**APPLICATION OF ACTIVE NOISE REDUCTION FOR HEARING PROTECTION AND SPEECH INTELLIGIBILITY IMPROVEMENT**
H. J. M. STEENEKEN and G. LANGHOUT May 1985 23 p refs
(Contract A81/K/145)
(IZF-1985-7; TDCK-93143) Avail: NTIS HC A02/MF A01

Increase of the sound attenuation of an ear protector or a headset by the application of an Active Noise Reduction (ANR) system is discussed. As a result, the risk of hearing damage is decreased, and the quality of the communication increased. Methods to quantify these effects are described. Two ANR systems were evaluated with the measuring methods. It is found that an additional attenuation of 17 dB can be obtained at frequencies or = 500 Hz. It is concluded that the application of ANR systems is advantageous for hearing protection and speech communication in military environments. Author (ESA)

**N86-18133#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.
**HELICOPTER INTERNAL NOISE TREATMENT. RECENT METHODOLOGIES AND PRACTICAL APPLICATIONS**
H. J. MARZE and F. N. DAMBRA 1985 15 p Presented at 11th European Rotorcraft Forum, London, England, 10-13 Sep. 1985
(SNIAS-852-210-102) Avail: NTIS HC A02/MF A01

A methodology including helicopter noise diagnosis, definition of acoustic treatment best adapted for each panel structure, and the development, tests and improvements of internal noise treatments is set up. Noise spectra are obtained at several cabin locations and helicopter speeds. An array of noise transducers placed at 120 locations allows to set the acoustic power radiated by each structure subassembly. It is shown that the method gives a good representation the wave pattern, and it may provide sufficient detail to efficiently reduce the added weight of sound proofing treatments. Author (ESA)

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-21872#**
**LIFE CYCLE COST AND AVAILABILITY IN MILITARY AERONAUTICS [COUT DE POSSESSION ET DISPONIBILITE EN AERONAUTIQUE MILITAIRE]**
F. LESUEUR (Avions Marcel Dassault-Breguet Aviation, Division Systemes d'Armes, Saint-Cloud, France), A. DEMOMENT (Crouzet, S.A., Division Aerospatiale, Valence, France), and R. ECK (Societe Francaise d'Equipements pour la Navigation Aerienne, Division Pilotage et Systemes, Velizy-Villacoublay, France) IN: International Colloquium on Reliability and Maintainability, 4th, Tregastel, France, May 21-25, 1984, Proceedings. Volume 2 . Lannion, France, Centre National d'Etudes des Telecommunications, 1984, p. 455-459. In French. Research supported by the Service Technique des Telecommunications et des Equipements Aeronautiques.

The present study is concerned with an approach to evaluate the efficiency of a weapons system. A life cycle cost model adapted to the French Air Force is considered, taking into account the costs for study and development, acquisition, and operation. The relative effect of the different parameters is discussed. The concept of operational availability is explored, and the different factors for modelling it are analyzed. Attention is given to hypotheses and limits, the various parts of a mission, the weapons system, maintenance, and aspects of modelling. It is pointed out that the two model concepts for life cycle cost and operational availability represent factors which can be used separately and jointly in the evaluation of a weapons system. G.R.

**A86-22076#**
**OPERATING EXPERIENCE IN THE JEFF (A) IN THE ARCTIC**
J. J. EDWARDS (RMI Co., National City, CA) ASME, International Gas Turbine Conference and Exhibit, 30th, Houston, TX, Mar. 18-21, 1985. 6 p.
(ASME PAPER 85-GT-127)

The present article is concerned with studies regarding the use of air cushion vehicles (ACV) in the Arctic. These studies included the use of the Jeff (A), an air cushion landing craft obtained from the U.S. Navy, for operations in Alaska. It is pointed out that the overall performance of Jeff (A) running in the Arctic after the incorporation of relatively few cold weather modifications was truly commendable. The modifications included the use of compliant or low viscosity materials at the operating temperature. In addition, it was found to be important to keep equipment warm, or at least in a state in which the cooling to extremely cold temperatures would be avoided. After these requirements were satisfied, craft performance became more than satisfactory. In January of 1984, the Jeff (A) initiated cargo service to Mukluk Island in support of drilling activity. G.R.

**A86-22141#**
**AIRFRAME DESIGN TO ACHIEVE MINIMUM COST**
B.R. NOTON (Battelle Memorial Institute, Columbus, OH) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 18-1 to 18-11. refs

Cost drivers related to aircraft performance, design, material selection and manufacturing are discussed, and also those related to industry in general. The design objectives and manufacturing technology requirements for low-speed and high-speed aircraft are illustrated to indicate possible cost drivers. The importance of the early developmental phases to reduce cost of engineering systems, is emphasized. To minimize cost drivers, the Air Force has developed a 'Manufacturing Cost/Design Guide' which puts designers on the lowest cost track early in the design phase and also enables trade-off studies to be conducted while developing alternative structural configurations. The methodology used to address cost drivers and to quantify these ae reviewed. Due to problems of cyclic production and stretched-out delivery schedules, some guidance is provided to designers with respect to the importance of learning curves. A worksheet is provided for designers to summarize the cost of parts, subassemblies and the program aircraft. Author

**A86-22399**
**SMALL PROPULSION ENGINE LCC CONSIDERATIONS**
P. E. LAUVER (Teledyne, Inc., Teledyne CAE Div., Toledo, OH) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 348-353. refs

This paper identifies the need to analyze propulsion system cost effectiveness. Current engine life cycle cost (LCC) analysis capabilities are discussed and examples are presented. The differences between aircraft and missile engine LCC factors are identified. Current efforts to address the unique problems of missile engine LCC are summarized. Author

**N86-17233#** Netherlands Agency for Aerospace Programs, Delft.
**ACTIVITIES REPORT IN AIRCRAFT DEVELOPMENT AND ASTRONAUTICS Annual Report, 1984 [VERSLAG VAN DE WERKZAAMHEDEN 1984]**
1984 34 p In DUTCH
Avail: NTIS HC A03/MF A01

The Fokker 50 and the Fokker 100 aircraft development activities are reviewed. The data acquisition, recording, and evaluation system for flight tests with prototypes, the Airbus, and the Shorts SD 330/360 is described. Contributions to the IRAS-project; and ESA-programs (telecommunication satellites, Ariane, Eureca, microgravity, Earth observation, Spacelab, Columbus) are summarized. Author (ESA)

**N86-18252#** National Aerospace Lab., Amsterdam (Netherlands). Informatics and Fluid Dynamics Div.
**ENGINEERING DATA INTERACTIVE PRESENTATION AND ANALYSIS SYSTEM (EDIPAS): A GENERAL APPROACH TO ENGINEERING DATA MANAGEMENT AND ANALYSIS APPLIED TO WIND TUNNEL TESTING**
R. K. VANDERDRAAI and F. J. HEEREMA 8 Sep. 1983 41 p refs Submitted for publication
(NLR-MP-83057-U; B8566269) Avail: NTIS HC A03/MF A01

Utilizing database management and interactive graphics techniques, the Engineering Data Interactive Presentation and Analysis System (EDIPAS) was designed and implemented for aircraft development. Data management facilities are provided in EDIPAS to cope with the data transfer problem. Basic facilities to tailor analysis and presentation functions to the needs of various disciplines are available. Examples of application of EDIPAS for experiments in wind tunnels are given. Author (ESA)

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# GENERAL

**A86-22129#**
**THE WRIGHT BROTHERS EXPERIENCE IN THE EVOLUTION OF AIRCRAFT DESIGN, STRUCTURES, AND MATERIALS**
C. A. DEMPSEY (Wright B. Flyer, Inc., Dayton, OH) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 1-1 to 1-13. refs

This paper discusses the work of the Wright Brothers in the evolution of aircraft design, structures, and materials. It describes and gives specific details about their efforts in establishing requirements for the aircraft development program. Influence of the requirements on the new technology development process is discussed with regard to the three axis flight control system, structures, materials, and air vehicles performance. The transition of this technology to later aviation developments is discussed. The paper does not cover the entire Wright Brothers program but clearly defines their procedure in conservative innovation and standardized design technique. It further shows that the 1902 glider (Wright Brothers patent) was the culmination of their research, since this vehicle became the standard for all their other activities. Author

**A86-22130#**
**AIRCRAFT DESIGN - FROM THE MYTH OF MAKE-DO TO MACH 3**
R. P. HALLION (USAF, Flight Test Center, Edwards AFB, CA) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 2-1 to 2-5.

The development of aerospace vehicle design technology has always been dependent upon a strong data base derived from analytical studies, ground, and flight research. An examination of the history of aircraft design reveals several major periods from the Wright brothers through the end of the 1950's during which new technological capabilities were developed, refined, and put into practice with both military and civilian aircraft. Author

**A86-22135#**
**THE EVOLUTION OF RECIPROCATING ENGINES AT LYCOMING**
A. E. LIGHT (Avco Corp., Avco Lycoming Williamsport Div., Williamsport, PA) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 9-1 to 9-4.

The paper summarizes the history of reciprocating engines at Lycoming from production of automotive engines in 1910 through present production of general aviation engines in 1984. Technical advancements and specification of early automotive, radial aircraft, and present opposed cylinder engines are induced. Lycoming has developed reciprocating engines from 30 horsepower to 5,000 horsepower. Lycoming holds FAA type certificates for over 600 reciprocating aircraft engine models. Author

**A86-22137#**

**X-15 HIGH TEMPERATURE ADVANCED STRUCTURE**

J. RAPP (Rockwell International Corp., El Segundo, CA) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 13-1 to 13-3.

The X-15 Advanced Research Vehicle was a design challenge with problems not even envisioned at the outset. The objective was to design and build a manned space flight vehicle capable of very high speed and altitude which could be used to study effects of weightlessness in space. The greatest problem to solve was to select materials to withstand extremely high temperatures to be encountered and then to develop techniques to fabricate and assemble them. Additional structural problems resulted from differential heating of external skins and the sub-structure, which caused a twofold dilemma of secondary induced stresses while simultaneously reducing the allowables. The vehicle also had to have flight control systems that would operate above the atmosphere and after engine burnout. Author

**A86-22138#**

**X-20 STRUCTURES OVERVIEW**

A. K. HEPLER (Boeing Aerospace Co., Seattle, WA) IN: Evolution of Aircraft/Aerospace Structures and Materials Symposium, Dayton, OH, April 24, 25, 1985, Proceedings . Dayton, OH, American Institute of Aeronautics and Astronautics, 1985, p. 14-1 to 14-8.

The material and structural development during the X-20 (Dyna-Solar) Program demonstrated the feasibility of a multimission aircraft primary structural system capable of operating at temperatures up to 1650 F. Further, coated refractory alloys were developed for use in leading edge shells and in outer surface panels where temperatures up to 2900 F were experienced. The material and structural design concepts obtained during the X-20 Program represent the bulk of todays (1985) technology for high temperature aircraft structural systems. These validated data provide an excellent source for supporting the conceptual definition of hot structure airframe systems for Advanced Military Aircraft as the Transatmospheric Vehicle (TAV). Author

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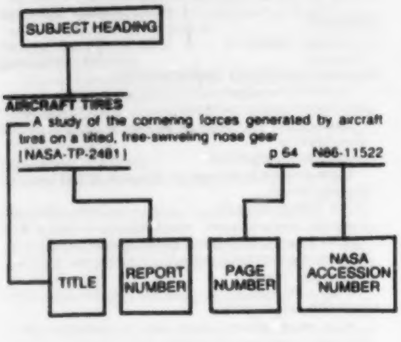
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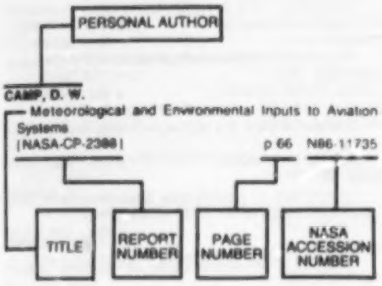

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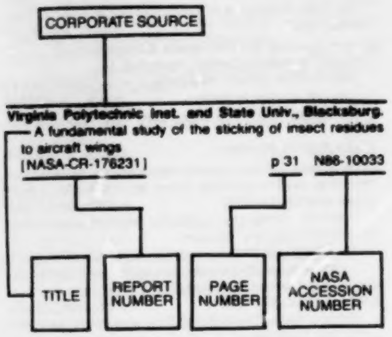
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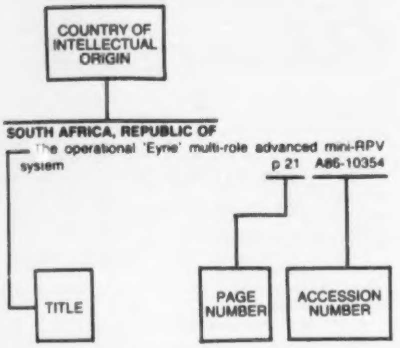
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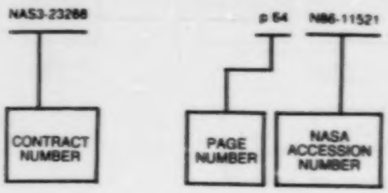

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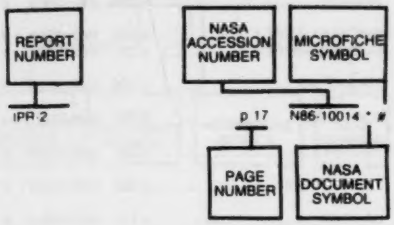

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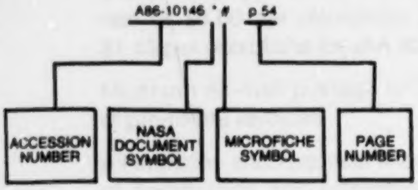

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**N86-10033*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.
**A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs
(Contract NAG1-300)
(NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

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**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS**
D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

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Aeronautical Engineering
A Continuing Bibliography with Indexes
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## ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

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| STAR (N-10000 Series) | N86-18284 – N86-20340 |
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NASA SP-7037(201)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

## (Supplement 201)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in May 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Branch 1986
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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 438 reports, journal articles, and other documents originally announced in May 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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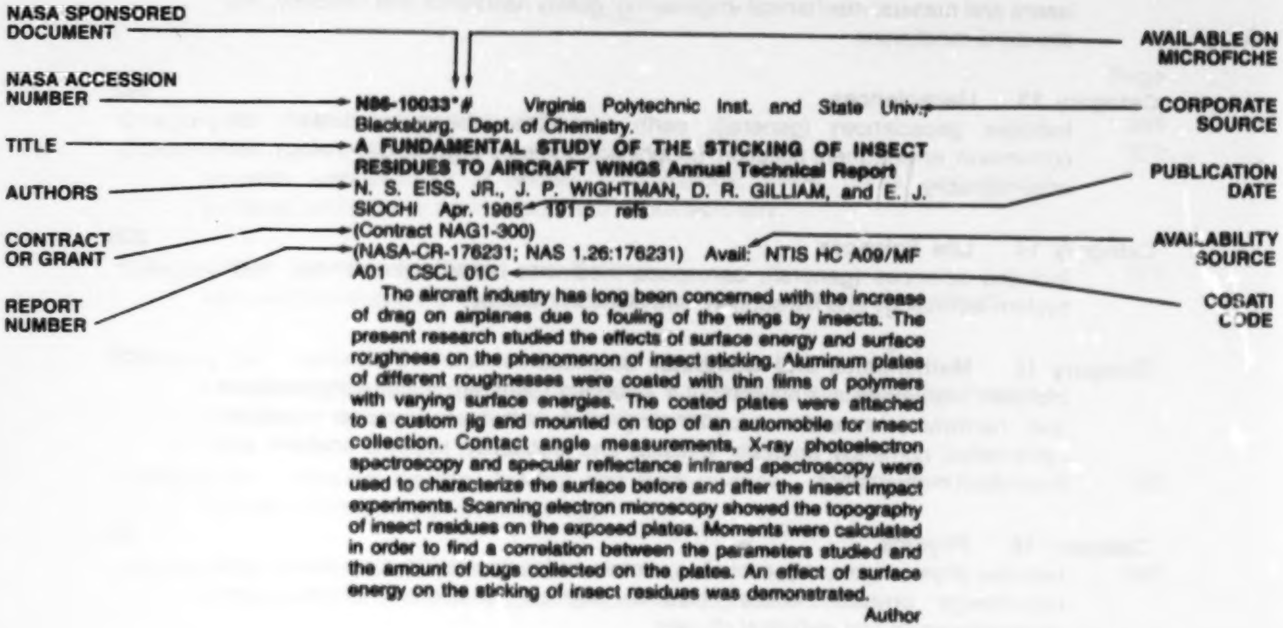
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**N86-10033*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.
**A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs
(Contract NAG1-300)
(NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

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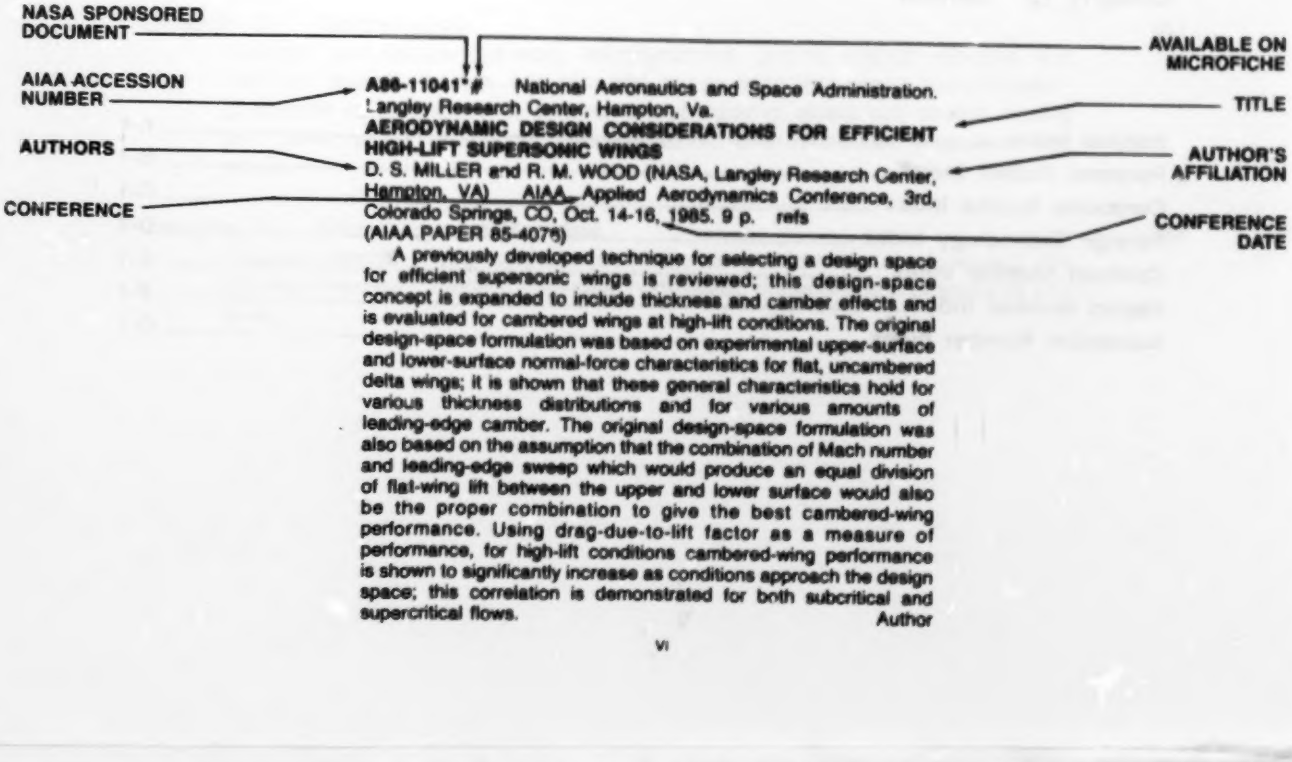
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**A86-11041*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS**
D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 201)*

JUNE 1986

## 01

## AERONAUTICS (GENERAL)

**A86-23760**

**TESTABILITY OF AIRCRAFT [KONTROLOVATELNOST LETOUNU]**

J. VOLNY Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 227-231. In Czech.

The requirements for aircraft testability that are essential for the efficient maintenance and repair are summarized. In particular, attention is given to the philosophy of aircraft maintenance, maintenance scheduling, and methods, as well as to the relationship between reliability, testability, and the accessibility of aircraft parts and components during maintenance. The discussion also covers criteria for selecting a test method and the special features of aircraft intended for short-haul operation affecting the selection of the test procedure. Finally, the principal requirements for aircraft test equipment are examined. V.L.

**A86-25023**

**FUTURE HELICOPTER DEVELOPMENTS [ZUKUENFTIGE HUBSCHRAUBER-ENTWICKLUNGEN]**

P. HAMEL and B. GMELLIN (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 56-61. In German. refs

In the future, helicopters will have to satisfy very exacting demands with respect to both civil and military applications. The required enhancement of helicopter performance will be feasible on the basis of an increasing integration of new technologies. Related developments will include the employment of digital-electrical and digital-optical data transmission, microcomputer technology, and sensor and display technology. A higher-level objective of research in the area of flight mechanics is related to an evaluation of improvement possibilities regarding the mission-dependent flight characteristics and performance of helicopters which are more and more controlled automatically, taking into account the assurance of flight safety. Attention is given to a control system for automatic operations in the case of selected flight maneuvers, questions regarding the risks involved in the integration of new technologies, the role of wind tunnel simulation in connection with the consideration of new rotor systems, and the role of the pilot in the control of the helicopter. G.R.

**A86-25176#**

**RELIABILITY AND STRUCTURAL INSPECTION PROGRAM FOR TRANSPORT AEROPLANES**

G. FUJIWARA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 372, 1985, p. 1-11. In Japanese. refs

The principle and characteristics of the damage detection rating system for the structural inspection of transport aircraft are reviewed. The system consists of damage tolerance rating, environmental deterioration rating, and accidental damage rating systems. The characteristic functions of these systems are analyzed in relation to the reliability of the inspection and the structural safety requirements. The fleet leader and rotational sampling methods for the damage inspection and the selection method of structurally significant items are described. S.H.

**A86-25850**

**AFFORDABLE SAFETY**

J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 129, Jan. 25, 1986, p. 41-43.

Inspection procedures which will improve aircraft maintenance by reducing human error factors are examined. Examples of aircraft accidents which have occurred due to improper maintenance are presented. The utilization of improved accident reporting technique, such as affordable reporting and the confidential incident reporting system, is studied. The development of an independent internal safety audit system which increase communications between pilots and engineers for all airlines is analyzed. I.F.

**A86-26072#**

**ADVANCES IN SIMULATION, CONTROL AND GUIDANCE AND OTHER SYSTEMS FOR MANNED AND UNMANNED AIRCRAFT**

H. N. KRISHNAMURTHY (Aeronautical Development Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 35, April 1985, p. 171-193. refs

Recent advances in the areas of flight simulation and unmanned flight vehicles at the Aeronautical Development Establishment at Bangalore, India, are presented. Particular attention is paid to aspects of flight modeling and validation, simulation hardware, control and guidance, displays, flight management of manned and unmanned aircraft, design of unmanned flight vehicles, and light-weight structures. Consideration is given to the built-in energy-absorption systems designed to protect the peripheral aircraft structures against bird impact damage, and to shield the structures of unmanned vehicles that are likely to suffer from ground impact during the recovery phase. Block diagrams are included. I.S.

**A86-26114**

**THE WORLD AIRCRAFT INDUSTRY**

D. TODD (Manitoba, University, Winnipeg, Canada) and J. SIMPSON London/Dover, MA, Croom Helm/Auburn House Publishing Co., 1986, 282 p. refs

A comprehensive survey of the current state of the world aircraft industry is presented. The development of the industry and its current problems are considered. The role of governments is examined, showing how this differs from country to country. The prospects for the future shape of the industry, as newly industrialized countries become involved, are assessed. C.D.

**A86-26274**

**PLASTIC MEDIA BLAST BEST FOR STRIPPING**

J. B. BULLINGTON (U.S. Army, Production Engineering Div., Corpus Christi, TX) ManTech Journal, vol. 10, no. 4, 1985, p. 48-55.

A new cost-effect technique for paint stripping, which complies with nonpollution and safety standards is examined. The plastic media blast (PMB) process of removing acrylic and lacquer topcoats from epoxy prime surfaces, which is applicable to airframes, tail rotors, and composites, is analyzed; the advantages of the PMB technique are discussed. The need to prevent media and dust contamination of specific aircraft components is investigated. The design of the standard cabinet-type continuous-flow dry air blasting machine used in the PMB process is described. I.F.

**N86-18284#** Joint Publications Research Service, Arlington, Va.
**USSR REPORT: TRANSPORTATION**
4 Dec. 1985 67 p Transl. into ENGLISH from various Russian articles
(JPRS-UTR-85-014) Avail: NTIS HC A04

USSR Reports - Transportation (JPRS-UTR-85-014), 4 Dec. 1985, contains reports on Civil Aviation, Motor Vehicles and Highways, Rail Systems, and Maritime and River Fleets. Of particular interest in this issue are articles on air traffic control radar problems, and the use of laser technology to resurface worn aircraft parts.

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-22730#**
**INVESTIGATION OF A TIP CLEARANCE CASCADE IN A WATER ANALOGY RING**
J. A. H. GRAHAM (Pratt and Whitney Canada, Longueuil) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 108, Jan. 1986, p. 38-46. refs
(ASME PAPER 85-IGT-65)

The tip clearance flow region of high-pressure axial turbine blades for small gas turbine engines has been investigated in a water flow cascade. The blade model features variable clearance and variable endwall speeds. The cascade is scaled for Reynolds number and sized to give velocities suitable for visualization. Pressure profiles were measured on one blade, and correlated with the visualization. Unloading is found to be a major feature of the pressure field at both tip and midspan, and is intimately connected with scraping effects and the behavior of the clearance vortex. Some initial hot-film velocity measurements are also presented. Author

**A86-22732*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**AERODYNAMIC DETUNING ANALYSIS OF AN UNSTALLED SUPERSONIC TURBOFAN CASCADE**
D. HOYNIAK (NASA, Lewis Research, Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 108, Jan. 1986, p. 60-67. Previously announced in STAR as N85-26670. refs
(ASME PAPER 85-GT-192)

An approach to passive flutter control is aerodynamic detuning, defined as designed pasage-to-passage differences in the unsteady aerodynamic flow field of a rotor blade row. Thus, aerodynamic detuning directly affects the fundamental driving mechanism for flutter. A model to demonstrate the enhanced supersonic aeroelastic stability associated with aerodynamic detuning is developed. The stability of an aerodynamicaly detuned cascade operating in a supersonic inlet flow field with a subsonic leading edge locus analyzed, with the aerodynamic detuning accomplished by means of nonuniform circumferential spacing of adjacent rotor blades. The unsteady aerodynamic forces and moments on the blading are defined in terms of influence coefficients in a manner that permits the stability of both a conventional uniformally spaced rotor configuration as well as the detuned nonuniform circumferentialy spaced rotor to be determined. With Verdon's uniformly spaced Cascade B as a baseline, this analysis is then utilized to demonstrate the potential enhanced aeroelastic stability associated with this particular type of aerodynamic detuning. Author

**A86-23126*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.
**THE RESPONSE OF AIRFOILS TO PERIODIC DISTURBANCES - THE UNSTEADY KUTTA CONDITION**
D. R. POLING and D. P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 24, Feb. 1986, p. 193-199. NASA-supported research. refs
(AIAA PAPER 84-0050)

Two cases of unsteady flowfields over a NACA 0012 airfoil at an angle of attack are examined. The first is the classical pitching motion about the airfoil's quarter chord. The second is the flow over a fixed airfoil immersed in the wake of the pitching airfoil. Large reduced frequencies are examined. Measurements were obtained in a water tunnel by laser Doppler velocimetry. Ensemble-averaged velocity measurements were obtained in the vicinity of the trailing edges of both the pitching and the fixed airfoil. The results indicate that the classical unsteady Kutta condition is clearly not valid. An extension of this condition earlier proposed by Giesing and Maskell is examined and some evidence is provided for its support. Author

**A86-23133#**
**NUMERICAL SIMULATION OF LEADING-EDGE VORTEX FLOWS**
D. P. RIZZETTA and J. S. SHANG (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 24, Feb. 1986, p. 237-245. Previously cited in issue 17, p. 2424, Accession no. A84-37962. refs

**A86-23184*#** Illinois Univ., Urbana.
**A CLASS OF AIRFOILS HAVING FINITE TRAILING-EDGE PRESSURE GRADIENTS**
A. I. ORMSBEE (Illinois, University, Urbana) and M. D. DAUGHMER (Pennsylvania State University, University Park) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 97-103. Previously cited in issue 07, p. 840, Accession no. A85-19590. refs
(Contract NAG1-76)

**A86-23193#**
**COMPRESSIBILITY CORRECTIONS FOR MULTIFOIL SECTIONS**
A. HARRIS (De Havilland Aircraft of Canada, Ltd., Toronto, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 156-158. Research supported by the Department of National Defence of Canada. refs

The Lieblein and Stockman (1972) method for obtaining the compressible flow within a duct, as modified by Dietrich et al (1983) to yield a compressible flow correction for external flow, is presently applied to the case of a 24 percent-thick augmentor wing multifoil section in cruise configuration. The agreement between theory and experiment thus obtained is especially good in the case of the main airfoil section, confirming the applicability of the external compressibility correction to very thick sections. O.C.

**A86-23660**
**AERODYNAMIC DESIGN OF AN AIRFOIL WITH ALLOWANCE FOR THE CONDITION OF NONSEPARATED FLOW [AERODINAMICHESKOE PROEKTIROVANIE PROFILIA S UCHETOM USLOVIIA BEZOTRYVNOSTI]**
Z. KH. NUGMANOV, V. A. OVCHINNIKOV, and V. G. PAVLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 47-50. In Russian. refs

The paper is concerned with the problem of plotting the contour of an airfoil for a given surface pressure distribution using the theory of potential flow of an incompressible fluid. The airfoil coordinates are determined in the form of a series expansion in Jacobi polynomials whose coefficients are obtained from the flow line equation by the method of successive approximations. The law of pressure recovery beyond the maximum velocity point is expressed in the form of the Stratford analytical function, which ensures nonseparated flow in this region. Results of calculations are presented. V.L.

**A86-23770**

**NEW ASPECTS OF THE SMALL-PERTURBATION METHOD IN AERODYNAMICS [NOVE ASPEKTY METODY MALYCH PORUCH V AERODYNAMICE]**

Z. SKODA Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 325-328. In Czech. refs

Results obtained with a system for computing the aerodynamic derivatives of an entire aircraft by the method of discrete forces are summarized. The application of this method to nonstationary cases makes it possible to calculate generalized aerodynamic forces for the dynamic analysis of a flexible aircraft. The method of discrete forces is described with respect to the way in which it differs from the method of discrete vortices. B.J.

**A86-23775**

**PRACTICAL DIFFICULTIES IN THE THEORETICAL DESIGN OF LOW-SPEED PROFILES [PRAKTICKE OBTIZE PRI TEORETICKEM NAVRHU NIZKORYCHLOSTNICH PROFILU]**

P. BERAK Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 355-358. In Czech. refs

It is noted that results of programs for the design of low-speed profiles may be distorted by discretization deviations or by methodological simplifications. In an effort to overcome these difficulties, experience obtained with five programs is analyzed. It is concluded that high-quality profiles can be designed quickly when velocity distributions from proven profiles are applied. B.J.

**A86-23776**

**MEANS TO INCREASE THE LIFT ON AIRCRAFT WING PROFILES [PROSTREDKY KE ZVYSENI VZTLAKU NA PROFILECH KRIDEL LETADEL]**

J. MATULA Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 359-362. In Czech.

Techniques for increasing the center-line camber and the chord length near the leading and trailing edges are discussed as means to increase the lift on wing profiles. Attention is given to the effect of slat slots near the leading edge as well as to the effect of wing flaps near the trailing edge. B.J.

**A86-23777**

**DEVELOPMENT OF NUMERICAL METHODS OF EXTERNAL HIGH-SPEED AERODYNAMICS [VYVOJ NUMERICKYCH METOD VNEJSI AERODYNAMIKY VYSOKYCH RYCHLOSTI]**

M. KLADRUBSKY and K. KOZEL Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 363-370. In Czech. refs

Numerical methods involving the study of transonic flow past profiles or wings are reviewed for the period 1971 to the present. Particular attention is given to the development of such methods in Czechoslovakia. B.J.

**A86-23778**

**DISTRIBUTION OF OPTIMAL CIRCULATION ON A PROPELLER BLADE WITH A NONLINEAR DEPENDENCE ON THE NUMBER OF BLADES AND WITH ALLOWANCE TAPERING [ROZLOZENI OPTIMALNI CIRKULACE NA VRTULOVEM LISTU S NELINEARNI VAZBOU NA POCET LISTU A SE ZAHRNUTIM ZUZENI]**

S. SLAVIK Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 371-375. In Czech. refs

The aerodynamic design of a propeller is discussed from the viewpoint of maximum efficiency under the given conditions. A design principle based on the optimal circulation range is analyzed, and attention is given to the derivation of an explicit relation for the optimal circulation with allowance for tapering and the nonlinear dependence on the number of blades. B.J.

**A86-23780**

**PRESSURE FLUCTUATIONS ON THE EXTERNAL SURFACE OF AN AIRCRAFT [FLUKTUACE TLAKU NA VNEJSIM POVRCHU LETADEL]**

J. SULC Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 383-387. In Czech. refs

An intense pressure fluctuation field, variable in time and space, forms on the external surface of an aircraft in flight. The basic theoretical aspects of the generation of this field are discussed. An experimental method for investigating this phenomenon is then described; experimental results are presented; and applications to aircraft design are considered. B.J.

**A86-23830#**

**THE DEVELOPMENT OF A SECOND-GENERATION OF CONTROLLED DIFFUSION AIRFOILS FOR MULTISTAGE COMPRESSORS**

R. F. BEHLKE (United Technologies Corp., Pratt and Whitney Div., East Hartford, CT) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 11 p. refs
(ASME PAPER 85-IGT-9)

The evolution of Controlled Diffusion Airfoils is traced from inception of the theoretical design model to demonstration of significant performance gains at engine operating conditions in a multistage compressor rig. The proven aerodynamic benefits and versatility of first-generation Controlled Diffusion Airfoil blade elements are extended to the endwall flow region using an Integrated Core/Endwall Vortex design model to produce a new full span optimized second-generation Controlled Diffusion design. Highlighted are the essential roles of extensive cascade, low speed, large scale and high Mach number compressor rig testing in developing and substantiating the second generation Controlled Diffusion technology resulting in a 1.5 percent increase in efficiency and 30 percent increase in surge-free operation relative to first-generation Controlled Diffusion Airfoils. Author

**A86-23834#**

**AERODYNAMIC RESEARCH ON STRAIGHT WALL ANNULAR DIFFUSER FOR TURBOFAN AUGMENTOR**

Q. M. XIE and J. G. GU (China Gas Turbine Establishment, Jiangyou, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(ASME PAPER 85-IGT-16)

The effect of nonuniform inlet velocity and temperature profile on the aerodynamic performance of a straight wall annular diffuser for a turbofan augmentor has been investigated. The distribution of static pressure, stagnation pressure and temperature has been measured, thus pressure recovery coefficient, velocity profile and temperature profile at different axial station along the diffuser center line can be determined. The experimental results showed that the momentum ratio of two streams across the diffuser inlet flow splitter is the nondimensional flow parameter controlling diffuser aerodynamic performance. Thus, it is possible to simulate turbofan augmentor annular diffuser performance by using a low temperature air flow aerodynamic test under the condition that the diffusers are of similar geometry, have the same inlet velocity profile, and maintain the momentum ratio constant. A correlation for the velocity distribution in the diffuser was also obtained. Author

**A86-23948**

**AERODYNAMICS OF SWEPT WINGS WITH MEDIUM AND SMALL ASPECT RATIOS. II [AERODINAMIKA STRELOVIDNYKH KRYL'EV SREDNIKH I MALYKH UDLINENII. II]**

V. V. STRUMINSKII Moscow, AN SSSR, Sektor Mekhaniki Neodnorodnykh Sred, 1983, 63 p. In Russian.

Test results for sweptback (35, 45, and 60 deg) and sweptforward (-30 deg) wings with various aspect ratios are reported, and the characteristic features of flow past these wings are examined. In particular, an analysis is made of the effect of the sweep angle on the aerodynamic characteristics of aircraft over the full range of angles of attack. Solutions are obtained which make it possible to take advantage of the effect of slip in the wing cross-sections and improve the performance characteristics of swept wings. V.L.

**A86-24470**

**HEAT TRANSFER PROBLEMS IN AERO-ENGINES**

D. K. HENNECKE (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Heat and mass transfer in rotating machinery . Washington, DC, Hemisphere Publishing Corp., 1984, p. 353-379. refs

A survey of the heat transfer problems to be solved when developing an aircraft gas turbine engine is presented looking at each engine component separately. It is shown that the responsibilities of the heat transfer engineer have greatly increased. In addition to the design of the cooling system of the 'hot parts', such as the combustor and turbine, these include the evaluation and assessment of the thermal behavior of nearly all other parts such as the fan, compressor, labyrinth seals, bearings, etc. This is the result of the trend in aero-engines toward higher cycle pressures and temperatures, increased reliability with reduced engine weight, and ever tighter clearances to improve performance and, thus, achieve a further reduction in fuel consumption. It is shown that many heat transfer phenomena in aero-engines are not yet understood well enough. Therefore, heat transfer areas that need continued or intensified research are highlighted, demonstrating that many challenging problems remain to be tackled. Author

**A86-24471**

**FUNDAMENTAL HEAT TRANSFER RESEARCH FOR GAS TURBINE ENGINES NASA WORKSHOP OVERVIEW**

D. E. METZGER (Arizona State University, Tempe) IN: Heat and mass transfer in rotating machinery . Washington, DC, Hemisphere Publishing Corp., 1984, p. 381-396.

A review and discussion are presented of the objectives, organization, and results of a workshop sponsored by the Aerothermodynamics and Fuels Division, NASA Lewis Research Center, Cleveland, Ohio. The objective of the meeting was to assemble heat transfer specialists from USA industries, universities and government agencies to discuss approaches and priorities for the Center's future plans for research into gas turbine heat transfer fundamentals. Extensive input was solicited from and distributed to participants prior to the meeting. Those inputs, together with the subsequent meeting reports and recommendations, are reproduced and discussed in the present paper. Author

**A86-24522**

**POST STALL STUDIES OF UNTWISTED VARYING ASPECT RATIO BLADES WITH NACA 44XX SERIES. II - AIRFOIL SECTIONS**

C. OSTOWARI (Texas A & M University, College Station) and D. NAIK Wind Engineering (ISSN 0309-524X), vol. 9, no. 3, 1985, p. 149-164. refs

The present study is concerned with the poststall aerodynamic characteristics, lift, drag, and pitching moment, of untwisted constant chord blades as a function of airfoil thickness, aspect ratio, and Reynolds number. It is pointed out that these data are helpful for the design of cost-effective wind energy conversion devices. The conducted investigation of three-dimensional, cambered blades made use of the NACA 44XX series of airfoil sections. The presented results have been carefully selected with the objective to give the reader a fair representation of the aerodynamic ramifications of operating in deep stall conditions. G.R.

**A86-24627#**

**STUDIES OF THE AERODYNAMICS OF FLAPS AND SPOILERS IN UNSTEADY FLOW [ETUDES AERODYNAMIQUES DES VOLETS ET SPOILERS EN INSTATIONNAIRE]**

M. COSTES and M. RAHAINGOMANANA (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1985-149, 1985, 24 p. In French. refs
(ONERA, TP NO. 1985-149)

The experimental and theoretical research on control surfaces and control laws carried out by ONERA over the last decade are summarized. A prime goal of the program is to develop control laws with short response times for conditions such as unstable flight. Models for sinusoidal motions, the accompanying pressure response and the coefficient of pressure are presented, with quasi-steady values being derived from unsteady values that have a frequency which approaches zero. Trials at the Modane wind tunnel have included spoilers placed at various locations of the chord line and studied in two- and three-dimensional flows. Variations were introduced into the flow Mach number, the Re and the steady and unsteady flow parameters in developing the control laws. Steady-unsteady interactions with a trailing edge flap were found to have significant effects. The placement of a spoiler affected the appearance and magnitude of unsteady flow on a wing, causing oscillations which exceeded those of flaps on the trailing edge. Motions of either of the two types of the control surfaces produced unsteady flow and affected the efficiency of the wing used, a RA16SC1 profile. M.S.K.

**A86-24630#**

**A VISCOUS-INVISCID INTERACTION MODEL FOR TRANSONIC UNSTEADY FLOW [METHODE D'INTERACTION VISQUEUX-NONVISQUEUX POUR LE CALCUL DE DECOLLEMENT INSTATIONNAIRE TRANSSONIQUE]**

J. L. LE BALLEUR and P. GIRODROUX-LAVIGNE ONERA, TP, no. 1985-152, 1985, 35 p. In French. refs
(ONERA, TP NO. 1985-152)

A numerical method is presented for describing flows with viscous-inviscid interactions with or without separation and illustrated by examples. The model includes a two-equation model for turbulence solved by implicitly with a space-marching technique in both direct and inverse modes. A semi-implicit coupling method which features relaxation of the unsteady effects at the viscous boundary is made to converge at each time step and recapture the downstream viscous effects. The grid used is adaptable to the scale of the phenomena being studied and is also useful for modeling problems involving separation and shock-boundary layer interactions. Results are presented for sample calculations for steady and unsteady separated flows around NLR7301 and NACA64A010 airfoils. The influence of frequency is discussed, along with the effects of shock-induced separation. The model is capable of predicting the magnitude of buffeting which can be expected in transonic flows. M.S.K.

**A86-24634#**

**SOLUTION OF THE NAVIER-STOKES EQUATIONS IN A COMPRESSIBLE FLUID BY AN IMPLICIT METHOD [RESOLUTION DES EQUATIONS DE NAVIER-STOKES EN FLUIDE COMPRESSIBLE PAR UNE METHODE IMPLICITE]**

H. HOLLANDERS (ONERA, Chatillon-sous-Bagneux, France) and W. RAVALASON (Aerospatiale, Division Engins Tactiques, Paris, France) ONERA, TP, no. 1985-148, 1985, 43 p. In French. refs
(ONERA, TP NO. 1985-148)

An implicit finite-volume method which is second-order accurate, highly stable, and dissipative in weakly viscous regions, is presented for solving the time-dependent Navier-Stokes equations in integral form, and is applied to steady subsonic and transonic flow calculations over a NACA0012 airfoil in the laminar case, and over an ogive-cylinder projectile in the turbulent axisymmetric case. For turbulent flows, the mass-averaged Navier-Stokes equations are solved using a mixing-length eddy viscosity model. The results presented emphasize the good properties of stability and fast convergence of the method. Author

**A86-24642#**

### RECENT ADVANCES IN HELICOPTER AERODYNAMICS

J. J. PHILIPPE (ONERA, Chatillon-sous-Bagneux, France), P. ROESCH, A. M. DEQUIN, and A. CLER (Aerospatiale, Paris, France) ONERA, TP, no. 1985-166, 1985, 36 p. refs
(ONERA, TP NO. 1985-166)

The aerodynamics of isolated helicopter rotors and fuselages is addressed, and a few topics in interactional aerodynamics are also considered. Computational approaches to main rotor aerodynamics are examined, including simple blade element theory, prescribed wake models, distorted wake models, free wake models, and problems related to dynamic stall on the retreating blade, unsteady transonic flow on the advancing blade, blade deformations, and the rotor in hover flight. Experimental methods in wind tunnels to measure local and global performance as well as blade pressure are considered. Aspects of rotor design, including airfoil selection, blade twist, and blade planform are discussed. Experimental methods in fuselage aerodynamics are addressed considering problems in wind tunnel testing and examining fuselage drag and interactions in detail. The principal theoretical methods in fuselage aerodynamics are examined, including potential calculations, separated flow models, streamline boundary layer calculations, and wake calculations. C.D.

**A86-24703**

### STATOR ROW UNSTEADY AERODYNAMICS DUE TO WAKE EXCITATIONS

S. FLEETER and V. CAPECE (Purdue University, West Lafayette, IN) IN: Unsteady aerodynamics of turbomachines and propellers; Proceedings of the Symposium, Cambridge, England, September 24-27, 1984 . Cambridge, Cambridge University, 1984, p. 427-446. USAF-supported research. refs

The fundamental unsteady aerodynamics on a vane row of an axial flow research compressor stage are experimentally investigated, demonstrating the effects of airfoil camber and steady loading. In particular, the rotor wake generated unsteady surface pressure distributions on the first stage vane row are quantified over a range of operating conditions. These cambered airfoil unsteady data are correlated with predictions from a flat plate cascade inviscid flow model which considers both nonseparated and suction surface flow separation. At the design point, the unsteady pressure difference coefficient data exhibit excellent correlation with the nonseparated predictions, with the aerodynamic phase lag data exhibiting good trendwise correlation. The quantitative phase lag differences are associated with the camber of the airfoil. An aft suction surface flow separation region is indicated by the steady state surface static pressure data as the aerodynamic loading is increased. This separation affects the increased incidence angle unsteady pressure data, with these data correlating with the aft suction surface separated flow predictions. Author

**A86-24708**

### COMPARATIVE MEASUREMENTS OF THE UNSTEADY PRESSURES AND THE TIP-VORTEX PARAMETERS ON FOUR OSCILLATING WING TIP MODELS

W. J. WAGNER (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: Unsteady aerodynamics of turbomachines and propellers; Proceedings of the Symposium, Cambridge, England, September 24-27, 1984 . Cambridge, Cambridge University, 1984, p. 513-531. refs

Experimental investigations on steady and unsteady pressure distributions and on the tip vortex qualities of four wing tip configurations (rectangular tip, ogee tip, trapezoidal tip, swept tip) are presented and discussed. The analyses of the results show some unexpected phenomena such as double vortex structures and changing vortex structures during blade oscillation. The tip vortex qualities were investigated by means of an ultrasonic measuring device. The results give insight into the finer structure of the vortices and supply information on vortex position, core diameter and maximum velocity as well as vortex behavior if the blade is oscillated. All four configurations show a concave curvature of the lines of equal pressure on the region where the tip vortex originates. This is a sign of underpressure fields induced there. Author

**A86-24729*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### AERODYNAMIC PERFORMANCE OF TWO FIFTEEN-PERCENT-SCALE WIND-TUNNEL DRIVE FAN DESIGNS

D. B. SIGNOR (NASA, Ames Research Center, Moffett Field, CA) and H. V. BORST (Borst and Associates, Wayne, PA) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 21-35. refs
(AIAA PAPER 86-0734)

An experimental and analytical investigation of two fan blade designs was conducted. The fan blades tested were 15 percent scale models of the blades used in the National Full Scale Aerodynamic Complex fan drive at NASA Ames Research Center. The fan blades were composed of NACA-65 and modified NACA-65-series airfoil design sections. The blades with modified 65-series sections incorporated increased thickness on the upper surface, between the leading edge and the one-half chord position. Twist and taper were the same for both blade designs. The fan blades with modified 65-series sections were found to have an increase in stall margin when they were compared with the unmodified blades. The experimental performance data agreed favorably with theoretical calculations. Author

**A86-24732#**

### AN ESTIMATION [illegible] WALL INTERFERENCE ON A TWO-DIMENSIONAL CIRCULATION CONTROL AIRFOIL

N. J. WOOD (Stanford University, CA) and E. O. ROGERS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 57-63. refs
(AIAA PAPER 86-0738)

Tests in two different wind tunnels of the same series of circulation control airfoils has provided insight into the nature of tunnel wall interference on the data obtained from high lift airfoils. In particular, strong influence of the chord-to-height ratio is shown - in this case a 12 percent difference in the apparent (uncorrected) sensitivity of lift to jet momentum level. These performance changes are found to arise from differences in effective incidence and a correlation with existing interference theory is established. Substantiation of a simple technique (inviscid pressure distribution matching) for identifying the effective angle of attack directly from airfoil data is obtained by demonstrating a collapse of data from the two wind tunnels. As an important contribution to the aerodynamics of circulation control airfoils, the correction of the angle of attack to free air conditions has indicated that the mid-chord pitching moment is essentially decoupled from the blowing momentum. Author

**A86-24760#**

### AN EXPERIMENTAL STUDY OF A HIGH PERFORMANCE CANARD AIRFOIL WITH BOUNDARY LAYER TRIP AND VORTEX GENERATORS

M. G. BRAGG and G. M. GREGOREK (Ohio State University, Columbus) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 361-368.
(AIAA PAPER 86-0781)

The canard airfoil from the Voyager aircraft was tested in The Ohio State University's Subsonic Wind Tunnel. This highly optimized

laminar flow section has good clean airfoil performance but suffers severe lift and drag penalties with early boundary layer transition. These performance penalties result from a midchord boundary layer separation. An experimental program was conducted to document this problem and then to design and test vortex generators to improve the tripped airfoil performance while having the least affect on the clean airfoil. A set of properly designed vortex generators are shown along with the aerodynamic results to document their performance. A brief study of the effect of surface roughness in the turbulent boundary layer is also discussed.
Author

**A86-25005#**

### NAVIER-STOKES SOLUTIONS USING FINITE VOLUME PROCEDURES [NAVIER-STOKES LOESUNGEN MIT FINITEN VOLUMEN VERFAHREN]

D. SCHWAMBORN and E. KATZER (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) IN: Numerical aerodynamics - Current status in Germany; Symposium, Neubiberg, West Germany, July 2, 3, 1984, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1984, p. 54-60. In German. refs

A project whose goal is to develop a modular computer program system for solving the Navier-Stokes and Euler equations for various flow configurations is discussed. The types of configurations involved are described and subsidiary goals involved in the project are mentioned, including the study of the influence of the grid and of artificial dissipation. The present status of the project is summarized.
C.D.

**A86-25006#**

### NAVIER-STOKES PROCEDURE FOR SIMULATING TWO-DIMENSIONAL AND QUASI-TWO-DIMENSIONAL CASCADE FLOW [EIN NAVIER-STOKES VERFAHREN ZUR SIMULATION ZWEIDIMENSIONALER UND QUASI-ZWEIDIMENSIONALER GITTERSTROEMUNGEN]

O. SCHAEFER (Stuttgart, Universitaet, West Germany) IN: Numerical aerodynamics - Current status in Germany; Symposium, Neubiberg, West Germany, July 2, 3, 1984, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1984, p. 61-71. In German.

Improvements in the mathematical modelling, solution algorithm, grid, and boundary conditions pertaining to the numerical simulation of real flows through straight blade cascades are presented. These improvements make the calculative procedure more exact and efficient. Results using these improvements are presented for the NACA 8410 turbine cascade, separated laminar cascade flows, and subsonic flow through the 9C7 compressor cascade with strong sidewall contraction. Good agreement is obtained with comparable solutions and with measurements.
C.D.

**A86-25022**

### THE LAMINAR WING - A WAY FOR IMPROVING THE ECONOMY OF COMMERCIAL AIRCRAFT [DER LAMINARFLUEGEL - EIN WEG ZUR VERBESSERUNG DER WIRTSCHAFTLICHKEIT VON VERKEHRSFLUGZEUGEN]

K.-H. HORSTMANN, H. KOESTER, G. REDEKER, and A. QUAST (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 51-55. In German.

In the context of efforts to improve the economy of aircraft operations, new commercial aircraft with considerably reduced fuel consumption are being developed. Aerodynamics makes an important contribution to these efforts by providing new technologies which are capable to reduce drag. The national research program the 'Laminar Wing' is to establish the foundations for the use of a laminar wing with low drag characteristics in larger aircraft. The DFVLR is the initiator and an important partner in this program. It is pointed out that low-drag laminar wings are already employed in gliders for several decades. The technology of the laminar wing is discussed along with basic information regarding the determination of the laminar-turbulent transition, the design of laminar profiles for commercial aircraft, the economics of an operation of commercial aircraft with laminar wings, and problems arising in the case of a commercial aircraft with laminar wings. It is concluded that savings in fuel of approximately 30 percent in comparison to conventional aircraft are possible. G.R.

**A86-25084***  Massachusetts Inst. of Tech., Cambridge.

### ENERGETICS AND OPTIMUM MOTION OF OSCILLATING LIFTING SURFACES OF FINITE SPAN

A. R. AHMADI and S. E. WIDNALL (MIT, Cambridge, MA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 162, Jan. 1986, p. 261-282. Research supported by Bolt Beranek and Newman, Inc. refs
(Contract NGR-22-009-818)

In certain modes of animal propulsion in nature, such as bird flight and fish swimming, the efficiency compared to man-made vehicles is very high. In such cases, wing and tail motions are typically associated with relatively high Reynolds numbers, where viscous effects are confined to a thin boundary layer at the surface and a thin trailing wake. The propulsive forces, which are generated primarily by the inertial forces, can be calculated from potential-flow theory using linearized unsteady-wing theory (for small-amplitude oscillations). In the present study, a recently developed linearized, low-frequency, unsteady lifting-line theory is employed to calculate the (sectional and total) energetic quantities and optimum motion of an oscillating wing of finite span.
G.R.

**A86-25189#**

### DOUBLET STRIP METHOD FOR OSCILLATING RECTANGULAR WINGS IN SUBSONIC FLOW

A. ICHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 374, 1985, p. 152-159. In Japanese, with abstract in English. refs

An improved numerical method is presented for calculating the load distribution on oscillating rectangular wings in subsonic flow. The wing is divided into many chordwise strips. In the strips containing the control point, the kernel function is treated in the form of an expansion series, and spanwise integration is performed to obtain a chordwise logarithmic singularity. Through accurate evaluation of the singularity, the present method gives quick convergence and excellent computational efficiency to other current methods.
Author

**A86-25200#**

### IMPROVED DOUBLET LATTICE METHOD FOR OSCILLATING SWEPT TAPERED WINGS IN INCOMPRESSIBLE FLOW

A. ICHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 376, 1985, p. 296-303. In Japanese, with abstract in English. refs

An improved doublet lattice method is presented for calculating the load distributions on oscillating swept tapered wings in incompressible flow. The integration domain is transformed into a rectangular one, and the wing is divided into many chordwise strips. In the strip containing control points, Cauchy singularity and logarithmic singularity are properly accounted for. The solutions generally compare well with other lifting surface theories, but with much smaller computational times, and the method is found to be more accurate and to converge faster than conventional doublet lattice methods.
Author

**A86-25206#**

### RECENT COMPUTATIONAL FLUID DYNAMICS WORKS ABOUT HIGH ANGLE OF ATTACK AERODYNAMICS WITH SEPARATION VORTEX

K. FUJII Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 377, 1985, p. 339-350. In Japanese. refs

Recent developments in the numerical simulation of a separation vortex with a high angle of attack are reviewed. The numerical simulation methods include a time-marching method using the complete Navier-Stokes equations, the thin-layer Navier-Stokes equation, and the Euler equation, and a space-marching method using a parabolic Navier-Stokes equation, a thin-layer parabolic Navier-Stokes equation, and the Euler equation. S.H.

**A86-25207#**

**REVIEW OF THEORY OF VORTEX SEPARATED FROM A LEADING EDGE OF A DELTA WING**

S. KUBO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 377, 1985, p. 350-355. In Japanese. refs

Recent developments in the theory of vortex separation from a leading edge of a delta wing, and its future prospects are described. The concept of vortex lift of the delta wing based on the leading-edge separation analogy, the roll-up vortex layer theory, and the limit of the separation vortex from a leading edge of the delta wing are characterized. S.H.

**A86-25224#**

**AERODYNAMIC PERFORMANCES OF FABRIC SURFACE AIRFOILS**

M. KOBAYAKAWA and Y. KONDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 379, 1985, p. 491-494. In Japanese, with abstract in English. refs

Aerodynamic performances are measured for airfoils and circular cylinders with fabric surface. Generally, the critical Reynolds number for the drag of circular cylinder depends on the surface roughness. The measured results of the cylinders with fabric surface agree with Achenbach's results of sand roughness. The lift to drag ratios of the airfoil (NACA-0012) are much affected by fabric roughness. The differences of the lift to drag ratio between the different roughness are largest near their maximum values and decrease as the angle of attack increases. After the stall, no differences appear. The lift to drag ratio is also affected by the directions of stich. The lift to drag ratio decreases abruptly as k, the parameter of fabric roughness, increases to 0.2, but over this value its tendency becomes milder. Author

**A86-25227#**

**ON HYPERSONIC FLOW AROUND WINGED-VEHICLES AT HIGH ANGLES OF ATTACK**

M. YASUHARA, K. TSUBOI, N. FUKUDA, and K. SAKURAI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 380, 1985, p. 516-524. In Japanese, with abstract in English. refs

Experiments on hypersonic flow around a caret wing and a winged vehicle were conducted in a shock tunnel with a conical nozzle, at a Mach number of 8. Three force components and surface pressures were measured for a wide range of attack angle up to 45 deg, and compared with Newtonian flow theory, giving good comparisons for the nearly flat-bottomed models, except pitching moments. The source flow produced by the conical nozzle affects measured pressures and forces, and some corrections are necessary. Author

**A86-25233#**

**A STUDY ON THE PROPULSIVE FORCE OF WINGS IN NON-STEADY MOTION BY THE THEOREM OF MOMENTUM**

T. ICHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 381, 1985, p. 575-583. In Japanese, with abstract in English. refs

Propulsive force is considered of a two-dimensional airfoil executing a nonsteady out-of-plane motion from a standpoint of the theorem of momentum in the framework of the linear theory. By regarding the system of the airfoil and wake as a superposition of vortex pairs, it is shown that, for a harmonically oscillating airfoil, an appropriate form of the wake vortex sheet to give the correct propulsion is one that is determined under the influence of the upwash of the airfoil only. Concering the time mean of the propulsion of the oscillating airfoil, this approach is shown to be equivalent to the method for calculating the drag force of a cylindrical body using the Karaman vortex street. Author

**A86-25239#**

**TWO-DIMENSIONAL SCHEME 'DLM-C' TO EXAMINE SUBSONIC UNSTEADY LIFTING SURFACE SCHEMES FOR FINITE SPAN**

S. ANDO, M. KATO, and A. ICHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 382, 1985, p. 635-640. In Japanese, with abstract in English. refs

In order to investigate accuracy and convergence characteristics of any unsteady lifting surface computation programs, it is found that the 'DLM-C' scheme for two-dimensional airfoils is quite useful. This scheme is reliable up to high reduced frequencies k and high subsonic free stream Mach numbers M. It has comparable efficiency with NASA 2-D, within published k and M values. For a rectangular wing of aspect ratio ten, chordwise lift distributions on the midspan section are computed by using some unsteady lifting surface programs, which are compared with DLM-C. The values of error-index parameters E are entered in a k vs M diagram, and constant E curves are drawn. This diagram shows clearly the upper limit of k where the scheme is efficient. Author

**A86-25240#**

**AERODYNAMIC CHARACTERISTICS OF SLENDER WING-GAP-BODY COMBINATIONS. II**

Y. YAMAMOTO and S. ANDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 382, 1985, p. 641-648. In Japanese, with abstract in English. refs

Aerodynamic characteristics of slender wing-gap-body combinations are studied exactly in the framework of slender-body theory. In a previous paper, the solutions of total lift curve slope were obtained, in which the wings and the body have different incidence with respect to the free stream, and arbitrary width of chordwise gaps exist between the wings and body. In this work, the induced drag as well as the lift is evaluated exactly. This requires that the lift due to the wings and the lift due to the body are separately known. Many problems in which missile aerodynamicists have interest may be covered. Author

**A86-25599**

**AERODYNAMICS OF LIFTING SURFACES IN STEADY FLOW [AERODINAMIKA NESUSHCHIKH POVERKHNOSTEI V USTANOVIVSHEMSIA POTOKE]**

N. F. VOROBEV Novosibirsk, Izdatel'stvo Nauka, 1985, 240 p. In Russian. refs

Problems concerning subsonic and supersonic flow past surfaces are reduced to solving integral equations, and examples of exact solutions are presented. Green functions are determined for the wave equation for prismatic regions, which makes it possible to obtain solutions to problems of supersonic flow past complex configurations with allowance for reflection and diffraction phenomena. Approximations of solutions to integral equations are discussed; the convergence behavior of the discrete vortex method is analyzed. V.L.

**A86-25670**

**TEST CASES FOR THE PLANE POTENTIAL FLOW PAST MULTI-ELEMENT AEROFOILS**

A. SUDDHOO and I. M. HALL (Manchester, Victoria University, England) Aeronautical Journal (ISSN 0001-9240), vol. 89, Dec. 1985, p. 403-414.

The method of images is used to calculate the analytical solution for an inviscid incompressible flow past four arbitrary circles which are then conformally mapped onto aerofoil sections. The analytical solution of the corresponding flow past the system of aerofoils is obtained and the pressure distributions about a particular three-element and a particular four-element aerofoil are presented. These results are intended to be used to assess the accuracy of numerical methods. Author

**A86-26106*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AN EXPERIMENTAL INVESTIGATION OF THE PARALLEL BLADE-VORTEX INTERACTION**

F. X. CARADONNA, G. H. LAUB, and C. TUNG (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 29 p. Previously announced in STAR as N85-13777. refs

A scheme for investigating the parallel blade vortex interaction (BVI) has been designed and tested. The scheme involves setting a vortex generator upstream of a nonlifting rotor so that the vortex interacts with the blade at the forward azimuth. The method has revealed two propagation mechanisms: a type C shock propagation from the leading edge induced by the vortex at high tip speeds, and a rapid but continuous pressure pulse associated with the proximity of the vortex to the leading edge. The latter is thought to be the more important source. The effects of Mach number and vortex proximity are discussed. Author

**A86-26107#**

**SOME CALCULATIONS OF TIP VORTEX - BLADE LOADINGS**

N. BALTAS and G. J. HANCOCK (Queen Mary College, London, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 9 p.

Transient tip vortex-blade loadings are calculated from an inviscid steady model in which the tip vortex is idealized as a discrete line vortex while the blade loading is represented by a vortex lattice arrangement. Mach number effects are neglected. Author

**A86-26108#**

**A CONSISTENT MATHEMATICAL MODEL TO SIMULATE STEADY AND UNSTEADY ROTOR-BLADE AERODYNAMICS**

U. LEISS (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 16 p. refs

A general formulation has been developed to simulate the stalled and unstalled aerodynamic coefficients of a rotor blade in steady and unsteady flow. The main features of the present method are few empirical parameters with physical background in the full range in angle of attack and Mach number without the need to sectionize the validity of parameters. The method takes account for different types of steady stall and the influence of Reynolds number. Unsteady effects due to pitch, plunge and fore and aft motion are separately implemented. The calculated steady normal force coefficient curve and the unsteady hysteresis loops of the present method match very well with the two-dimensional test data, even for high frequencies. In addition some comparisons with other methods are presented. Aerodynamic rotor forces can be obtained by analytical integration of the section forces over the span of the blade and analytical derivatives of these forces are possible. Author

**A86-26109#**

**COMPARATIVE MEASUREMENTS OF THE UNSTEADY PRESSURES AND THE TIP-VORTEX PARAMETERS OF FOUR OSCILLATING WING TIP MODELS**

W. J. WAGNER (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p. refs

Experimental investigations on steady and unsteady pressure distributions and on the tip vortex qualities of four wing tip configurations (rectangular tip, Ogee tip, trapezoidal tip, swept tip) are presented and discussed. The tip vortex qualities were investigated by means of an ultrasonic measuring device. The results give insight into the finer structure of the vortices and supply information on vortex position, core diameter and maximum velocity as well as vortex behavior if the blade is oscillated. This is demonstrated by a selection of a few single conditions. Author

**A86-26110#**

**RADIAL DISTRIBUTION CIRCULATION OF A ROTOR IN HOVER MEASURED BY LASER VELOCIMETER**

M. NSI MBA, C. MEYLAN, C. MARESCA, and D. FAVIER (Aix-Marseille II, Universite, Marseille, France) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 15 p. refs
(Contract DRET-82-432)

A laser velocimeter was used to determine the circulation by integration of the velocity vector along a contour surrounding the blade section of a helicopter in hover. Two different contours were tested and compared. The radial distribution of circulation were then measured for rotors of different tip shape (rectangular, parabolic, tapered, swept) and presented comparatively to numerical results based on a free wake analysis code. Author

**A86-26112#**

**THEORETICAL PREDICTION OF RUNNING-TIME MEASUREMENTS IN UNSTEADY FLOW**

W. SEND (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p. refs

The results obtained for the present theoretical predictions of running time measurements, in the context of an investigation of various rotor blade tip clearances, are aimed at a deeper understanding of vorticity formation and concentration in the wake of a blade. The physical assumptions for the flow are infinitely high Reynolds number and incompressible flow, which lead to a simplified vorticity transport equation. Attention is given to the analytical solution of the three-dimensional wake integral in unsteady flow, which permits fast and precise computation of induced velocity fields. Theoretical and experimental results are compared for two different profiles in the cases of reduced frequency, amplitude, and steady angle-of-incidence. O.C.

**N86-18287#** National Research Council of Canada, Ottawa (Ontario). High Speed Aerodynamics Lab.

**SUBSONIC WALL INTERFERENCE CORRECTIONS FOR HALF-MODEL TESTS USING SPARSE WALL PRESSURE DATA**

M. MOKRY Nov. 1985 35 p refs Presented at the Euromech Colloquium No. 187 on Adaptive Wall Wind Tunnels and Wall Interference Correction Methods, Goettingen, West Germany, 15-17 Oct. 1984
(LR-616; NRC-25132) Avail: NTIS HC A03/MF A01

A method is described for correcting subsonic wind tunnel measurements on half-models in ventilated test sections, operated at subcritical flow conditions at the walls. For perforated walls, the boundary values of the streamwise component of the wall interference velocity are obtained from static pressures measured by a few longitudinal pressure tubes or rails attached to the walls and from the estimated farfield of the model in free air. The sparse boundary data is extended by means of streamwise smoothing and transverse interpolation. The streamwise velocity correction is derived from the doublet panel solution of an interior Dirichlet problem and the transverse corrections by integrating the irrotational flow conditions. The evaluated corrections to Mach number and angle of attack, presented as contour plots in the wing plane, provide insight into the correctability of the test results. Examples are given for a transport aircraft half-model tested in the NAE high speed wind tunnel. Applicability of the method at supercritical flow conditions at the model is examined on experimental and computational data of a high aspect ratio wing. Author

**N86-18289*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMPRESSIBLE, UNSTEADY LIFTING-SURFACE THEORY FOR A HELICOPTER ROTOR IN FORWARD FLIGHT**

H. L. RUNYAN and H. TAI Dec. 1985 21 p refs
(NASA-TP-2503; L-15976; NAS 1.60:2503) Avail: NTIS HC A02/MF A01 CSCL 01A

A lifting-surface theory has been developed for a helicopter rotor in forward flight for compressible and incompressible flow. The method utilizes the concept of the linearized acceleration potential and makes use of the doublet lattice procedure. Calculations demonstrating the application of the method are given in terms of the lift distribution on a one-bladed rotor, a two-bladed rotor, and a rotor with swept-forward and swept-back tips. Also, the lift on a rotor vibrating in a pitching mode at 4 per revolution is given. Compressibility effects and interference effects for a two-bladed rotor are discussed. Author

**N86-18294#** Army Research and Technology Labs., Moffett Field, Calif. Aeromechanics Lab.

**CALCULATION OF HELICOPTER AIRFOIL CHARACTERISTICS FOR HIGH TIP-SPEED APPLICATIONS**

W. J. MCCROSKEY, J. D. BAEDER, and J. O. BRIDGEMAN 17 May 1985 16 p Presented at the 41st Annual Forum for the American Helicopter Society, Fort Worth, Tex., 15-17 May 1985
(AD-A160694) Avail: NTIS HC A02/MF A01 CSCL 20D

In this paper, we have applied a new aerodynamic tool to the study of helicopter airfoil characteristics. We have shown that the computed airloads reproduce completely the experimental behavior of representative airfoils across the transonic regime. In addition, the computational details of the flow fields, the surface pressure distributions, and the viscous-layer characteristics enable us to trace the evolution of the physical changes that occur as m infinity or Re increases. Descriptions of the complicated development of shock waves, shock-induced separation supplement the information that has been obtained heretofore in wind tunnels. In validating our calculations and assessing the accuracy of the results, including extensive grid-refinement studies and comparisons with data from numerous wind tunnels, we have defined more precisely the capabilities and limitations of the code ARC2D. This important aspect of the investigations can complement wind-tunnel tests, by providing flow-field details that are difficult to measure and by extending the range of flow parameters beyond the capabilities of existing wind tunnels. The code has now progressed from a purely research stage to almost a production stage, where it can be run by specialists in the helicopter industry. GRA

**N86-18296#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**THE CONFORMAL REPRESENTATION OF THE NACA 642A015 PROFILE [DE CONFORME AFBEELDING VAN HET PROFIEL NACA 642A015]**

J. J. H. BLOM Apr. 1984 51 p refs In DUTCH
(VTH-M-502) Avail: NTIS HC A04/MF A01

In order to construct a wind tunnel model of the symmetric NACA 642A015 airfoil profile, a Timman based airfoil transformation method was used. A smoother and tighter contour profile is obtained. The number of profile coordinates (z-plane) is brought up to 100 points, equidistantly situated on the circle contour (zeta-plane). Adjacent coordinates are calculated using Schoenberg interpolation polynomials. Author (ESA)

**N86-18301#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**CALCULATION OF THE EXTERNAL NACELLE SURFACE FOR SINGLE AND DOUBLE STREAM JET ENGINES FOR CIVIL AIRCRAFT [DE BEREKENING VAN HET OMSPOELD GONDELOPPERVLAK VAN ENKEL- EN DUBBELSTROOM STRAALMOTOREN VOOR CIVIELE VLIEGTUIGEN]**

E. TORENBEEK and G. H. BERENSCHOT Jan. 1983 40 p refs In DUTCH
(VTH-M-445) Avail: NTIS HC A03/MF A01

Simple formulas to be used in the conceptual design phase of civil aircraft for the calculation of principal dimensions and external surface of nacelles for single and double stream engines with turbocompressors are derived and verified. Nacelle surfaces of 35 engines, used in existing or planned aircraft, are determined to verify the formulas. Missing essential dimensions, such as inlet diameter and nacelle length, are referred to performance magnitudes such as bypass ratio and propulsion. Introducing (semi-) static relations, formulas whose applicability depends on available data are derived. An accuracy of 6.5% is reached; the most simple formula has a standard deviation of 12%. Author (ESA)

**N86-18303#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

**ON THE LONGEST CHORD OF THE FIRST MULLER PROFILE [OVER DE LANGSTE KOORDE VAN HET EERSTE PROFIEL VAN MUELLER]**

J. J. H. BLOM Oct. 1983 20 p refs In DUTCH
(VTH-M-486) Avail: NTIS HC A02/MF A01

Using literature data, the coordinates, front point, and longest chord, defined as the largest distance between the sharp profile back edge and a point of the profile contour (= the front point) of the Muller wing profile were determined. A simpler transformation function for profile parameters, such as tail angle, curvature, and thickness, used in a Timman based iterative airfoil transformation program, is provided by Muller. Before profile forms can be compared with each other, a normalization on the longest chord is required. The tangent to the contour in the front point is at right angle to the longest chord. For so-called classical profile families, relations indicating exactly the front point can be derived. Author (ESA)

**N86-18304#** Eidgenoessisches Flugzeugwerk, Emmen (Switzerland). Research and Testing Dept.

**PARAMETRIC DETERMINATION OF LIFT INTERFERENCE FOR THREE-DIMENSIONAL MODELS IN THE EMMEN (SWITZERLAND) AIRCRAFT WORKS WIND TUNNEL**

G. CAPITAINE 31 Aug. 1984 35 p refs In GERMAN; ENGLISH summary
(F+W-FO-1740) Avail: NTIS HC A03/MF A01

Wind tunnel wall interference effects on the flow around a model were investigated for correction of the test values. A FORTRAN 77 program is developed for determination of the lift interference correction with specific slit parameters and porosity parameters for a three-dimensional compressible flow in a rectangular test section with slotted top and botton walls and closed vertical walls. The numerical procedure is applied to entire configurations and semiconfigurations. The results are plotted on charts to determine the variations of the lift correction and streamline curvature factors for different slit parameters. Author (ESA)

**N86-19283** Purdue Univ., West Lafayette, Ind.

**AN EXPERIMENTAL INVESTIGATION OF PROPELLER WAKES USING A LASER DOPPLER VELOCIMETER Ph.D. Thesis**

R. M. SUNDAR 1985 196 p
Avail: Univ. Microfilms Order No. DA8520081

This report presents a detailed investigation of the performance and flowfield of three single rotation propellers. These propellers were designed to demonstrate the efficiency improvements attainable by using proplets and biblades. Direct measurement of thrust by a parallelogram balance and power by measuring the input to the propulsion unit (dc motor) was used to determine the efficiency of the propellers. The force measurements demonstrated that the use of proplets did produce an efficiency improvement under high loading conditions in static operation as well as with forward speed. The improvement in static thrust by using proplets was comparable with that of a shrouded propeller. The flow field in the wake of the propellers was investigated with an LDV system. The measured velocity field is compared with the theoretical velocity field. Biot-Savarts' law was applied to the theoretically assumed vortex geometry in the wake to determine the theoretical velocity field. Dissert. Abstr.

**N86-19284#** Committee on Science and Technology (U. S. House).
**HIGH SPEED AERONAUTICS**
Washington GPO 1985 195 p Hearing before the Subcommittee on Transportation, Aviation and Materials of the Committee on Science and Technology, 99th Congress, 1st Session, no. 21, 24 Jul. 1985
(GPO-51-341) Avail: Subcommittee on Transportation, Aviation and Materials

Testimonies on the research and development of hypersonic speed aviation is presented. The effect of high speed aircraft on space flight is noted. The need to press forward in this research in order to keep up with other countries is emphasized. Budgetary requirements are also considered. E.R.

**N86-19285#** National Aeronautical Establishment, Ottawa (Ontario). High Speed Aerodynamics Lab.
**ANALYSIS OF EXPERIMENTAL DATA FOR A 21% THICK NATURAL LAMINAR FLOW AIRFOIL, NAE68-060-21:1**
D. J. JONES and M. KHALID Oct. 1985 56 p refs
(NAE-AN-34; NRC-25076; AD-A162914) Avail: NTIS HC A04/MF A01

Results obtained from wind tunnel tests on a 21% thick supercritical airfoil capable of sustaining long runs of laminar flow on both surfaces are presented. The measured drag levels are superior to those of any model previously tested in this facility and are comparable to classical NACA and modern NASA NLF airfoils. Author

**N86-19286#** National Aerospace Lab., Tokyo (Japan).
**AERODYNAMIC TRANSFER FUNCTIONS FOR A FINITE WING IN INCOMPRESSIBLE FLOW**
H. MATSUSHITA 1985 58 p refs In JAPANESE; ENGLISH summary
(NAL-TR-867; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

The aerodynamic transfer functions for a wing with a control surface in an incompressible flow are presented analytically using Laplace transform technique. The aerodynamic transfer function for an airfoil can be analytically represented with the generalized Theodorsen function as circulatory parts and the rational function as noncirculatory parts. The aerodynamic transfer function for a finite wing is obtained in a closed form which includes the nonrational function called a modified circulation. A modified circulation function shows a finite wing effect and is governed by an integro-differential equation, which can be solved efficiently by numerical computation. These results extend the simple harmonic theory to a general transient motion. With the expression thus obtained, the characteristics of the aerodynamic transfer function for a finite wing clearly show that it should have a branch point at the origin and have no singularities along the negative real axis. Transient aerodynamic forces in time domain such as an indicial lifts are obtained by inverse Laplace transforming the present results. Comparison of these results with the other methods and the experimental values shows a good agreement. Author

**N86-19287*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**LOW-SPEED WIND-TUNNEL INVESTIGATION OF THE EFFECT OF STRAKES AND NOSE MACHINES ON LATERAL-DIRECTIONAL STABILITY OF A FIGHTER CONFIGURATION**
J. M. BRANDON Washington Feb. 1986 33 p refs
(NASA-TM-87641; L-16051; NAS 1.15:87641) Avail: NTIS HC A03/MF A01 CSCL 01A

A series of low-speed static wind-tunnel force tests were conducted on a 0.15-scale model of a modern high-performance fighter aircraft. The tests identified the use of nose chines to enhance stability at high angles of attack. Results of this investigation showed that the strake was the major contributor to directional instability. The destabilizing forces were created by two mechanisms: (1) adverse flow in the region of the vertical tail, and (2) forces generated on the fuselage ahead of the center of gravity. Properly designed nose chines effectively negated the adverse flow near the vertical tail and created stabilizing forces on the forebody in the range of the stall angle of attack. Author

**N86-19288*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**LOADS AND AEROELASTICITY DIVISION RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS FOR FY 1985 AND PLANS FOR FY 1986**
J. E. GARDNER and S. C. DIXON Jan. 1986 125 p
(NASA-TM-87676; NAS 1.15:87676) Avail: NTIS HC A06/MF A01 CSCL 01A

The Langley Research Center Loads and Aeroelasticity Division's research accomplishments for FY85 and research plans for FY86 are presented. The work under each branch (technical area) will be described in terms of highlights of accomplishments during the past year and highlights of plans for the current year as they relate to five year plans for each technical area. This information will be useful in program coordination with other government organizations and industry in areas of mutual interest. Author

**N86-19291#** Naval Surface Weapons Center, Silver Spring, Md.
**GENERATION OF THE STARTING PLANE FLOWFIELD FOR SUPERSONIC FLOW OVER A SPHERICALLY CAPPED BODY**
T. HSIEH and F. J. PRIOLO 9 May 1985 286 p
(AD-A161117; NSWC/TR-84-484) Avail: NTIS HC A13/MF A01 CSCL 20D

This report describes a fast method to provide a three dimensional starting flowfield to be used in a space-marching-type calculation for the afterbody flowfield of spherically capped missiles at incidence in supersonic flight speed. Utilizing the property of spherical symmetry of the flowfield about a sphere, three dimensional starting plane flowfield may be interpolated from the results of an axisymmetric flowfield about a sphere, which is available from an existing computer program (NOSTIP) with considerably less computing time. The analysis of the interpolation method, examples and listings of computer programs for the axisymmetric and the three dimensional starting plane flowfields about a sphere in the Mach number range from 1.5 to 10 and angle of attack between 0 to 35 degrees are presented. Author (GRA)

**N86-19292#** National Aeronautical Establishment, Ottawa (Ontario).
**WIND TUNNEL CALIBRATION OF A PMS (PARTICLE MEASURING SYSTEMS) CANISTER INSTRUMENTED FOR AIRFLOW MEASUREMENT**
J. I. MACPHERSON Sep. 1985 64 p
(AD-A161124; NAE-AN-32; NRC-24922) Avail: NTIS HC A04/MF A01 CSCL 20F

Measurements of cloud particle images and concentrations using laser spectrometers housed in pods mounted on the wings or fuselages of research aircraft can be affected by the distortion of the airflow about the aircraft. The Flight Research Laboratory has developed a pod with a Rosemount 858 5-hole probe and pressure transducers to measure airflow angles and velocities at typical mounting locations on cloud physics research aircraft. This report documents the results of an extensive wind tunnel calibration of this pod to determine the factors relating the differential pressure measurements to the flow angles and velocities, and in particular to account for the effects of the canister itself on these measurements. Author (GRA)

**N86-19293#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**ON THE SEPARATED FLOW OVER A DELTA WING AT HIGH SUBSONIC AND TRANSONIC SPEEDS**
J. A. MOELLER, W. J. BANNIK, and P. G. BAKKER Dec. 1984 16 p refs Original contains color illustrations
(VTH-M-527) Avail: NTIS HC A02/MF A01

Wind tunnel results on the separated flow over a delta wing at high subsonic Mach numbers (0.55 to 0.85) were obtained for the validation of computer codes based on the Euler flow quations. The two models tested were of the same planform with flat upper surfaces and sharp leading edges, and cropped delta wings with 65 deg leading edge sweep. The larger model had a fuselage extending in front of the wing apex. It was used to study the flow by means of surface oil flow visualization, Schlieren pictures, and 5 hole directional probe flow field surveys at angles of incidence of 0, 5, 15, and 20 deg. With the smaller model, that had no fuselage, vortex breakdown was studied by Schlieren pictures. This model could reach a maximum angle of incidence of 35 deg. Author (ESA)

**N86-19294#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**ELEMENTS OF THE AERODYNAMIC THEORY OF CYCLOGYRO WING SYSTEMS WITH CONCENTRATOR EFFECTS**
R. COENE Oct. 1983 91 p refs
(VTH-LR-338) Avail: NTIS HC A05/MF A01

The fluid dynamics of cyclogyro wing systems are analyzed, based on two-dimensional potential flow theory. General expressions for flows associated with circular distributions of bound vorticity are derived. The forces and moments exerted by the flow on the bound vortices are calculated in their relation with the mass flux and the ground effect. The mean flows generated by wings with constant circulation are used as the environment in which energy exchange related to the shedding of vorticity can take place efficiently. Concentrator effects in the propeller and the turbine case are emphasized. For a wing system operating as a turbine with concentrator effects, the Lanchester-Betz limit for the conversion efficiency, 16/17, is invalid and can be increased. Wing systems operating as a propeller can generate thrust more efficiently when concentrator effects occur. Author (ESA)

**N86-19297#** Institut Franco-Allemand de Recherches, St. Louis (France).
**EXPERIMENTAL AND THEORETICAL STUDY OF INCOMPRESSIBLE FLOW AROUND A WING PROFILE WITH A SPOILER. CONTRIBUTIONS OF LASER VELOCIMETRY AND THE DVORAK METHOD Final Report [ETUDE EXPERIMENTALE ET THEORIQUE DE L'ECOULEMENT AUTOUR D'UN PROFIL D'AILE MUNI D'UN SPOILER D'EXTRADOS EN REGIME INCOMPRESSIBLE; CONTRIBUTION DE LA VELOCIMETRIE LASER ET DE LA METHODE DVORAK]**
P. MEYER, G. KOERBER, and R. KAUFFMANN 9 Jul. 1984 133 p refs In FRENCH
(Contract DRET-82-318)
(ISL-R-116/84) Avail: NTIS HC A07/MF A01

The RA16-SCI supercritical profile with spoiler was studied using two dimensional laser velocimetry. The measuring method is described. Experimental results for 3 incidences (10, 20 and 40 deg) and for a three-dimensional configuration are presented. A numerical computing method for separated flow is adapted to the spoiler case. Two types of separations are observed: a single recirculation bubble at 10 deg and the coexistence of two bubbles for 20 and 40 deg. The two components of the velocity field are obtained with good space resolution. The separated flow and the turbulent flow are described with enough detail and reproductibility. Author (ESA)

**N86-19298#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON AERODYNAMICS AND ACOUSTICS OF PROPELLERS**
P. POISSON-QUINTON (ONERA, Chatillon, France) Jul. 1985 43 p refs
(AGARD-AR-213; ISBN-92-835-1508-0) Avail: NTIS HC A03/MF A01

The Advisory Report contains a review and evaluation of the material presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamics and Acoustics of Propellers held in Toronto, Canada, 1 to 4 October 1984. Also included are related information from other sources and an excellent discussion of the state of art of modern propeller design and performance is presented. This Advisory Report was produced at the request of the Fluid Dynamics Panel of AGARD. Author

**N86-19299#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**TRANSONIC UNSTEADY AERODYNAMICS AND ITS AEROELASTIC APPLICATIONS**
Jun. 1985 51 p Proceedings of the 59th Meeting of the Structures and Materials Panel, Toulouse, France, 2-7 Sep. 1984
(AGARD-CP-374-ADD-1; ISBN-92-835-1501-3) Avail: NTIS HC A04/MF A01

The 59th meeting of the AGARD Structures and Materials Panel (SMP) was held on 3 to 7 September 1984 in Toulouse, France. It included a specialists' conference to discuss the latest methods of predicting transonic unsteady airloads for oscillating surfaces and flutter. Also considered were aeroelastic applications, many of which were made to standard configurations selected for the SMP cooperative program. The 16 papers and the round table discussion are summarized in some detail for coordination with AGARD's Fluid Dynamics Panel and Fluid Mechanics Panel. Author

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-23020**
**SMALL STONE IMPACT TESTING**
R. L. ANDERSON (Rosemount, Inc., Eden Prairie, MN) IN: Institute of Environmental Sciences, Annual Technical Meeting, 31st, Las Vegas, NV, April 30-May 2, 1985, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1985, p. 380-385.

Evaluation of the Foreign Object Damage (FOD) to an aircraft's fragile data instruments and sensitive external hardware is studied. The FOD testing facility, the Centrifugal Stone Accelerator, consists of a rotating motor-driven swingarm with a stone suspended from a flexible steel cable, and a Hall-effect sensor mounted on the DC shaft and hooked up to an RPM counter. The damage effected by a released 'standard stone' object, made of obsidion and about 0.25 oz weight and 0.6 in diameter, traveling at or in excess of 100 mph is assessed. Results of initial tests are presented. I.S.

**A86-23800**
**AN OVERVIEW OF CIVIL HELICOPTER OPERATIONS - PAST, PRESENT AND FUTURE**
E. M. BROWN Aerospace (ISSN 0305-0831), vol. 13, Jan. 1986, p. 20, 21, 24-27 .

The designing and developing of helicopters began with the development of the rotary wing. The effect of the turboshaft engine on helicopter designs is examined. The application of information obtained from military helicopters to civilian designs is analyzed. The development of fiberglass blades allowed for improvements in lift, speed, and fuel consumption, and lowered maintenance costs and noise levels. The uses of helicopters for aerial work, such as crop spraying, filming, inspection, transporting cargo, and for offshore support services are described. The focus of the third generation helicopters is on speed, reliability, safety, and comfort; technological advances in these areas are discussed. The design objectives for the fourth generation helicopters are studied. I.F.

**A86-25214#**
**EFFECTS OF MEASUREMENT ERRORS ON ESTIMATION OF THE PROBABILITY OF VERTICAL OVERLAP**
S. NAGAOKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 378, 1985, p. 403-410. In Japanese, with abstract in English. refs

This paper describes the effects of measurement errors on the distribution of relative vertical distances (RVD) from which the probability of vertical overlap of an aircraft pair can be estimated. As typical examples of probability density functions, the double exponential distribution and the double double exponential distribution are assumed for height keeping errors. Numerical examples suggest that the frequency in the central part (the core region) of RVD distribution in the presence of measurement errors becomes slightly less than that for the case when the measurement errors are not taken into account. On the other hand, the frequency in the tail region becomes slightly greater because of the presence of measurement errors. Author

**A86-25849**
**1985 - A TURNING POINT FOR SAFETY?**
D. LEARMOUNT Flight International (ISSN 0015-3710), vol. 129, Jan. 25, 1986, p. 27-32.

The need for stricter safety standards in order to reduce aircraft accidents is discussed. A list of fatal and nonfatal aircraft accidents in 1985 is presented; an increase from 451 deaths in 29 accidents in 1984 to 2,129 deaths in 40 accidents in 1985 is observed. Due to a large number of accidents involving engine failure, the efficiency of jet engine designs and inspection procedures is examined. The role of the US FAA and UK Civilian Aviation Authority in improving and enforcing safety standards are described. I.F.

**A86-26127#**
**A FIRST STEP FOR REDUCING HELICOPTER IFR APPROACH MINIMA AGUSTA A109 IFR CAT II CERTIFICATION**
F. BANAL and G. ZANETTI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 15 p.

The advantages and drawbacks of lowering the helicopter IFR weather minima using the current ILS system at airports are reviewed. The certification program to obtain FAA STC for IFR CAT II operations of the Agusta A109A, Mk I helicopter is described. It is shown how the flight evaluation results of that program demonstrate the possibility of changing the present helicopter requirements. C.D.

**A86-26128#**
**AIRWORTHINESS ASPECTS OF FATIGUE IN HELICOPTERS**
J. W. BRISTOW (Civil Aviation Authority, Airworthiness Div., Redhill, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 14 p. refs

Problems in the current practice of component fatigue substantiation for civil helicopters in the U. K., and CAA guidelines to reduce the relatively high number of accidents (in comparison to that of fixed-wing aircraft), are discussed. An analysis of fatigue-related helicopter failures reveals specific problems such as wear, corrosion, and increased loads that are to be targeted for improvements. Steps taken in the direction of the damage tolerance principles set out in a 1984 report are outlined. They include maintaining existing factor levels on fatigue strength, e.g. 1.6 for aluminum and 1.4 for steel. Where damage tolerance has been shown to be impractical, a more rigorous safe-life substantiation is recommended such as the use of SN curves based on realistically tested components and more representative testing of the magnitude of the loads, the stress distribution, and the number of cycles of helicopter flights. Load spectrum and helicopter failure data are included. R.R.

**A86-26151#**
**DETERMINATION OF LIMITATIONS FOR HELICOPTER SHIP-BORNE OPERATIONS**
C. F. G. M. HOFMANN and R. FANG (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 19 p.

The factors influencing helicopter-ship operations are reviewed. The determination of these factors in various qualification program elements and their use in setting up a flight test program aboard ship are examined. The performance of those flight tests and the relevant safety and efficiency constraints are described, and the use during the tests of data obtained in previous program elements in discussed. The application of the test team's previous experience to minimize flying hours without affecting the quality of the test results is examined. C.D.

**N86-18306#** National Transportation Safety Board, Washington, D. C. Bureau of Technology.
**GENERAL AVIATION CRASHWORTHINESS PROJECT, PHASE 3: ACCELERATION LOADS AND VELOCITY CHANGES OF SURVIVABLE GENERAL AVIATION ACCIDENTS Safety Report, 1972-1981**
4 Sep. 1985 189 p
(NTSB/SR-85/02) Avail: NTIS HC A09/MF A01

This report is the last in a series of three issued by the National Transportation Safety Board as a result of its General Aviation Crashworthiness Program. Its purpose is to provide information to support changes in crashworthiness design standards for seating and restraint systems in general aviation airplanes. Phase One presents a methodology for documenting impact severity. Phase Two presents specific data on survivable accidents which demonstrate that if all occupants wear shoulder harnesses, fatalities are expected to be reduced by 20 percent. Eighty-eight percent of the seriously injured persons in survivable crashes are expected to experience significantly fewer life-threatening injuries. The Phase Three report provides analytical results of actual crashes. The values of acceleration loads and velocity changes that occupants can sustain in survivable, modern general aviation airplane accidents are defined. This report also discusses specific crashworthiness problems including sea/restraint systems that failed, shoulder harnesses that were not worn, and inadequate or nonexistent seat stroking ability. Author

**N86-18307#** Naval Research Lab., Washington, D. C.
**THE AIRCRAFT ICING ENVIRONMENT IN WINTERTIME, LOW CEILING CONDITIONS Final Report**
N. B. GUTTMAN, R. K. JECK, M. R. HENDERSON, and M. D. MUELLER 28 Oct. 1985 74 p
(AD-A160578; NRL-MR-5650) Avail: NTIS HC A04/MF A01 CSCL 09B

Radiosonde (Raob) temperature and humidity data were used to deduce the vertical distribution of clouds and aircraft icing conditions near Washington, D.C. when low ceilings (- or 1000 ft)(0/3 km) occurred along with surface temperatures near freezing. Automated predictions of the vertical distribution of icing probability, type, and severity were generated from the Raob data. The technique employs a U.S. Air Force method that has been computerized by one of the authors (RKJ) for use on Hewlett Packard model 9845 computers. The predictions were compared with pilot reports from the vicinity and reasonable agreement was found. GRA

**N86-18308#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

**AN ELECTRONIC INDEX OF ARTICLES PERTAINING TO AIR FORCE TRANSPORTATION IN THE POST-WORLD WAR 2 ERA, WITH ABSTRACTS OF SELECTED ARTICLES M.S. Thesis**

F. R. ANIBLE Sep. 1985 41 p
(AD-A160837; AFIT/GLM/LSM/85S-1) Avail: NTIS HC A03/MF A01 CSCL 15E

This thesis designed and compiled an electronic index system to catalog articles in military, transportation, and aviation periodicals published during the period 1947 through 1957 and pertaining to transportation and its relationship to the U.S. Air Force. The system consists of a Master Index giving the title, author, publication, and date of over 1,000 articles, with abstracts of selected articles. Separate alphabetical Author, Title, and Subject Indexes are cross-referenced to the Master Index through a simple numerical code system. The indexes are stored on 5-1/4 inch flexible magnetic diskettes which are placed in pockets fastened into the front and back covers of the copy of the thesis kept in the Library of the School of Systems and Logistics, Air Force Institute of Technology. The articles indexed are those dealing with transportation modes and vehicles owned, operated, used, contracted, and leased by the Air force operations. In addition, source pertaining to the interface of Air Force airlift operations and operations of other services are included. GRA

**N86-18309#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS: BRIEF FORMATS, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 1 OF 1984 ACCIDENTS**

18 Jun. 1985 402 p
(PB85-916920; NTSB/AAB-85/20) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent $160.00/year; all others write for quote CSCL 01B

Selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984 are given. The 200 general aviation and air carrier accidents represent a random selection. The facts, conditions, circumstances and probable cause(s) for each accident are given. Additional statistical information is tabulated by type of operation and type of aircraft. GRA

**N86-18310#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT US CIVIL AND FOREIGN AVIATION, ISSUE 2 OF 1984 ACCIDENTS**

12 Jul. 1985 406 p
(PB85-916921; NSTB/AAB-85/21) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent $160.00/year; all others write for quote CSCL 01B

Selected aircraft accident reports are given in a brief format. The accidents occurred in U.S. civil and foreign aviation operations during calendar year 1984. The 200 general aviation and air carrier accidents represent a random selection. The facts, conditions, circumstances and probable causes(s) for each accident are given. Additional statistical information is tabulated by type of operation and type of aircraft. GRA

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-22729**

**THE TELEMETRY SYSTEM OF THE DFVLR EXPERIMENTAL AIRCRAFT ATTAS [DAS TELEMETRIESYSTEM DES DFVLR-FLUGVERSUCHSTRAEGERS ATTAS]**

H. BOTHE (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) IN: European Telemetry Conference, 7th, Boeblingen, West Germany, May 21-24, 1984, Reports. Part 2 . Wessling, West Germany, Arbeitskreis Telemetrie, 1984, p. 8.12-8.12.13. In German.

For flight tests related to studies in the area of Flight Mechanics/Flight Control, an aircraft is currently being prepared by a German aerospace company for use as an Advanced Technologies Testing Aircraft System (ATTAS). In a basic stage, the modifications will make it possible to conduct studies related to in-flight simulations, active control, flight control functions with thrust control, cockpit design, 4D control with inclusion of data link, mission management (fuel saving), the operational testing of landing systems, traffic flow control, and data transmission and processing in digital flight control systems (serial bus systems). The modifications needed in the aircraft are discussed, giving attention to the measurement and data transmission system. G.R.

**A86-23268**

**TELEMETRY SYSTEM PROTOTYPE DEVELOPMENT**

W. R. HUMMEL (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 17-1 to 17-6.

The Naval Air Test Center at Patuxent River, MD has been using the Real-Time Telemetry Processing System to monitor test flights since 1973. A prototype for its replacement is currently under development. The objectives, design goals, and features of the system are described and compared with the existing system. Author

**A86-23376**

**MODE-S BEACON SYSTEM TO COVER ALL U.S. UPPER AIRSPACE BY 1991**

J. L. BAKER (Westinghouse Electric Corp., Pittsburgh, PA), P. N. MCCABE (System Development Corp., Santa Monica, CA), and K. V. BYRAM (FAA, Washington, DC) ICAO Bulletin, vol. 40, Dec. 1985, p. 14-17.

The design of the Mode-S beacon system, which will modernize air traffic control systems by increasing the reporting accuracy of aircraft positions while reducing interference, is studied. The Mode-S system provides monopulse processing, selective interrogation, and a two-way data link. The capabilities of the radio-frequency and pulse processing hardware of the computer controlled interrogator subsystem are examined. The hardware components and functions of the data processing subsystem, which controls real-time scheduling and processing of surveillance and communication data, and communication and surveillance interfacing, are investigated; the subsystem contains transaction processing, monitoring, and data extraction programs. The advantages the Mode-S system provides due to its expandability and flexibility are described. I.F.

**A86-23379**
**SIMPLE TECHNIQUE MOISTUREPROOFS ILS LOCALIZER ANTENNA ARRAY**
S. M. IRULAPPAN and S. C. MAJUMDAR (Civil Aviation Department, New Delhi, India) ICAO Bulletin, vol. 40, Dec. 1985, p. 26-28.

A method of protecting the dipole elements of the localizer antenna array from rain and moisture, in order to maintain the performance level, is examined. The requirements for the ILS localizer course alignment and radiation integrity are discussed. The configuration of the antenna's 12 dipole elements, which are mounted in front of a reflector having an 85 ft aperture, is described. The application and installation of 115 cm x 150 cm polyethylene bags over each dipole are analyzed. I.F.

**A86-24533**
**AIRCRAFT APPROACH GUIDANCE USING RELATIVE LORAN-C NAVIGATION**
A. L. ELIAS (MIT, Cambridge, MA) Navigation (ISSN 0028-1522), vol. 32, Spring 1985, p. 1-15. refs

Tests performed at, and in behalf of, the State of Vermont led to the first Supplemental Type Certificate for en route use of Loran-C under Instrument Flight Rules. The results of these tests led to a resurgence of interest in the use of Loran-C as a general-purpose national aeronautical radio-navigation system. The main obstacle to the use of Loran-C for final approach to landing guidance is the error due to variations in the propagation speed of the Loran-C signals caused by changes in the terrain's dielectric properties. A 'relative navigation' technique has been proposed for improving the accuracy. The present paper provides the results of two additional studies, taking into account variable signal-to-noise ratio (SNR)/variable acceleration tradeoffs, and small position changes from the reference point. G.R.

**A86-25025**
**INERTIAL NAVIGATION - THE BEGINNINGS OF AN INGENIOUS INVENTION [TRAEGHEITSNAVIGATION - AUS DEN ANFAENGEN EINER GENIALEN ERFINDUNG]**
L. SCHMIEDER DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 64-67. In German.

The present paper is concerned with the development of inertial navigation, taking into account the time from its invention by Boykow (1911) to the official admission of an inertial platform for U.S. aircraft in the year 1968. It is pointed out that, according to these dates, the development of inertial navigation, from the first concept to technological maturity, has required a time period of 57 years. Attention is given to the article in which Boykow (1911) first describes the characteristics of his new invention and its advantages for the navigation of an aircraft, a patent application submitted by Boykow's company (1926), problems related to friction in the bearings and an approach for overcoming those problems, new advances made by Boykow as incorporated in a patent application (1935), a picture of the inertial platform according to Boykow's concepts, developments related to the 84-minute pendulum, and advances described in a patent applied for by Draper et al. (1951). G.R.

**A86-26133#**
**ANTENNA SITING ON HELICOPTERS**
B. AUDONE (Aeritalia S.p.A., Caselle Torinese, Italy) and G. MESCHI (Costruzioni Aeronautiche Giovannia Agusta S.p.A., Cascina Costa, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p. refs

The antenna siting activity on helicopters is described with special attention paid to electromagnetic problems. The importance of the prediction of antenna performances at the early stage of the project is stressed pointing out the importance of computer aids. Test facilities are also described for performing antenna pattern measurements, which represent the most difficult task of the overall activity. Author

**N86-18311#** National Aerospace Lab., Tokyo (Japan).
**CALIBRATION OF AN ON-GROUND AIRCRAFT TRACKING RADAR BY AERIAL PHOTOGRAMMETRY**
K. YAZAWA, T. INAGAKI, T. ONO, and T. OKA Jun. 1985 42 p refs In JAPANESE; ENGLISH summary
(NAL-TR-861; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

An on-ground tracking radar is calibrated for obtaining the accurate position of an aircraft during flight testing. The calibration was performed by aerial photogrammetry for estimating the position and the attitude of an aircraft compared with synchronized data from tracking radar. The accuracy of aerial photogrammetry using a non-metric camera is less than 0.2% of the flight altitude from ground. The accuracy corresponds to an angle of 0.01 degree at 1000m height and 10km distance from the radar. It is comparable to the resolution of the radar. Author

**N86-18312#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**PROBABILISTIC EVALUATION OF INDIVIDUAL AIRCRAFT TRACKING TECHNIQUES M.S. Thesis**
R. L. WILKINSON Sep. 1985 146 p
(AD-A160146; AFIT/GSM/ENS/85S-32) Avail: NTIS HC A07/MF A01 CSCL 01C

A study was conducted in order to demonstrate a technique for comparing the outputs of various individual aircraft tracking (IAT) systems. There were two objectives: (1) to determine the distribution of structural lives that could be expected based on a single IAT scenario, and (2) to evaluate the feasibility of replacing the current universal IAT safety factor with specific statistical calculations that consider the strengths and weaknesses of each IAT system. The ultimate goal of this thesis was to begin the transition of individual aircraft tracking from a deterministic approach to a stochastic one. A simulation was performed which included twelve aircraft, each flying five different load history variations at three gross weights. Initial structural damage was assumed based on a reset flaw size after nondestructive inspection. Structural lives were normally distributed with a mean of approximately 4700 flight hours. The cracks present at the one-half lifetime depot inspection were lognormally distributed. Using these distributions, the probabilities of structural failure were calculated for several inspection intervals. Repeating this process for other IAT scenarios would allow a direct comparison of various IAT systems. Eventually, such a process could lead to individual system safety factors, rather that the current universal safety factor. GRA

**N86-19303** New South Wales Univ., Kensington (Australia).
**SIGNAL PROCESSING IN THE AIRBORNE RECEIVER OF THE INTERSCAN MICROWAVE LANDING SYSTEM Abstract Only**
D. L. DILLON Mar. 1985 3 p
Avail: Issuing Activity

The history and evolution of microwave landing system (MLS) is reviewed. The strategy by which the various MLS functions are sequentially transmitted in accordance with a standardized signal-in-space format is described, making possible the interoperability of ground and airborne subsystems of widely differing sophistication. The meaning of MLS error, its causes and the rationale for the accuracy requirements of the MLS are discussed. The overall task to be performed by the airborne MLS subsystem and the MLS receiver are surveyed. The impact on the processing on MLS signals by interfering propagation effects is considered, together with a review of some MLS signal processing methodologies. A preferred technique is identified. The question of the required sampling rate to implement the signal processing digitally is considered, and a pulse centroid-detection algorithm is described. E.A.K.

**N86-19304*** National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.

**VIDEO PROCESSOR FOR AIR TRAFFIC CONTROL BEACON SYSTEM Patent**

F. BYRNE, inventor (to NASA) 10 Sep. 1985 5 p Filed 28 Sep. 1982
(NASA-CASE-KSC-11155-1; US-PATENT-4,540,986; US-PATENT-APPL-SN-425201; US-PATENT-CLASS-343-6.8-R)
Avail: US Patent and Trademark Office CSCL 17G

A circuit is disclosed for use in a transponder located in an aircraft or the like for identifying a true side lobe suppression signal being transmitted by a ground located transmitted system. The true side lobe suppression signal includes at least pulses P1 and P2. The circuit causes the transponder to produce reply signal upon the amplitude of the P1 pulse being a predetermined ratio to said P2 pulse. The circuit includes a pair of transistors with a capacitor connected to the output of the second transistor. The pulses P1 and P2 are supplied to the base electrode of the first transistor. Pulse P1 turns on the two transistors and charges the capacitor to a predetermined level so that when the second pulse P2 arrives, it does not turn on a transistor when it is equal to or less than the first pulse P1.

Official Gazette of the U.S. Patent and Trademark Office

**N86-19305#** Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.

**AUTOMATIC LANDING THROUGH THE TURBULENT PLANETARY BOUNDARY LAYER**

S. ZHU Nov. 1985 305 p refs
(UTIAS-289; ISSN-0082-5255) Avail: NTIS HC A14/MF A01

A statistical approach to automatic landing in turbulent planetary boundary layer is presented which is valuable for use in aircraft design and the analysis of terminal operation safety, also useful in design of autoland systems. The linearized equations of motion for an aircraft following a glide slope and an exponential curved path in the presence of wind shear and turbulence are developed. The effects of gust gradients on the motion were considered. The wind is modeled as a multi-dimensional random process, characterized by the mean wind shear and the turbulence. In the planetary boundary layer the mean wind is adequately described by a power law and by Weibull wind speed distribution. The turbulence is assumed locally isotropic. The modified von Karman model adequately represents correlations along an approach-flare trajectory. The forces and moments are considered to depend linearly on uniform gust and gust gradient components which are obtained by Etkin's four-point method which utilizes the air velocity at 4 points on the aircraft. As a test base, an autopilot of a jet transport for the approach and flare was designed. The Random Choice Direct Search technique was employed to find a set of optimal feedback gains for the auto-flare control system. Author

**N86-19306*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**HIGH DYNAMIC GPS RECEIVER VALIDATION DEMONSTRATION Final Report**

W. J. HURD, J. I. STATMAN, and V. A. VILNROTTER 31 Oct. 1985 208 p refs
(Contract NAS7-918)
(NASA-CR-176530; JPL-PUB-85-74; NAS 1.26:176530) Avail: NTIS HC A10/MF A01 CSCL 17G

The Validation Demonstration establishes that the high dynamic Global Positioning System (GPS) receiver concept developed at JPL meets the dynamic tracking requirements for range instrumentation of missiles and drones. It was demonstrated that the receiver can track the pseudorange and pseudorange rate of vehicles with acceleration in excess of 100 g and jerk in excess of 100 g/s, dynamics ten times more severe than specified for conventional High Dynamic GPS receivers. These results and analytic extensions to a complete system configuration establish that all range instrumentation requirements can be met. The receiver can be implemented in the 100 cu in volume required by all missiles and drones, and is ideally suited for transdigitizer or translator applications. Author

**N86-19308#** Mitre Corp., McLean, Va.

**POTENTIAL APPLICATIONS OF MULTIPLE INSTRUMENT APPROACH CONCEPTS AT 101 U.S. AIRPORTS**

A. C. SILVA and J. N. BARRER Sep. 1985 150 p
(Contract DTFA01-84-C-00001)
(AD-A161155; MTR-85W65; FAA-DL5-85-2) Avail: NTIS HC A07/MF A01 CSCL 01E

Concepts for conducting multiple IFR Approaches to airports include: (1) Independent and Dependent parallel approaches at reduced runway separations. (2) Converging approaches to non-intersecting and to intersecting runways. (3) Triple arrival streams to parallel and non-parallel runways. (4) The application of these concepts to the use of separate short runways and segregated traffic streams. This report summarizes a survey of 101 U.S. Airports to determine potential applications of the above concepts. The survey identified many potential applications of each of the concepts using existing runways: (1) Parallel approaches - 25 airports; (2) Converging approaches - 74 airports; (3) Triple approaches - 6 airports; and (4) Use of separate short runways -60 airports. GRA

# 05

# AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-23022**

**SOME THOUGHTS ON THE VIBRATION TESTING OF HELICOPTER EQUIPMENT IN THE UK**

J. C. BARKER (Westland Helicopters, Ltd., Yeovil, England) and H. GOLDBERG (GEC Avionics, Ltd., Borehamwood, England) IN: Institute of Environmental Sciences, Annual Technical Meeting, 31st, Las Vegas, NV, April 30-May 2, 1985, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1985, p. 420-430.

The history of the changes in the design requirements set by the Joint Airworthiness Committee for the United Kingdom military helicopters is reviewed, with reference to the mechanical and environmental sources of vibration. Rotor sources are given special attention, while other mechanical components which can induce vibration (shafts, rotor gear boxes, hydraulic pumps, turboengines, tailplanes, and fins) are briefly discussed. Results of a data survey, undertaken to produce quantitative basis for drafting additional specifications, are presented and compared with the old MIL Standard 810D formulae. Based on these results and on comparison with the U.S. helicopters, standards for the minimum-vibration designs, and a new testing philosophy were drafted. A flow chart of testing procedures, and data survey results are included. I.S.

**A86-23185#**

**INFLUENCE OF NONLINEAR BLADE DAMPING ON HELICOPTER GROUND RESONANCE INSTABILITY**

D. M. TANG and E. H. DOWELL (Duke University, Durham, NC) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 104-110. refs
(Contract NSF MEA-83-15193)

The lagging motion of each helicopter blade is assumed to be of equal amplitude and equally apportioned phase, thus allowing a simplified analytical method to be used to calculate the ground resonance instability of a helicopter model with nonlinear dampers in both the landing gear and blades. The geometrical nonlinearities of the blade lag motion and the influence of initial disturbances on ground resonance instability are also discussed. Finally an experiment is carried out using a helicopter scale model. The experimental data agree well with analysis. Author

**A86-23190#**

**AEROACOUSTICS OF AN ADVANCED PROPELLER DESIGN UNDER TAKEKOFF AND LANDING CONDITIONS**

S. FUJII, H. NISHIWAKI, and K. TAKEDA (National Aerospace Laboratory, Tokyo, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 136-141. Research supported by the Environment Protection Agency of Japan. refs

Three configurations of six-bladed, 400-mm-diam, scale-model advanced propellers such as backward-, forward-, and back-forward alternately installed swept blades were tested in anechoic environments with an incoming main flow velocity up to 68 m/s. The data for the advance ratio of 0.43-1.15 were obtained in the aeroacoustic aspects. The arrangement of alternately swept blades showed the best quality among the three configurations in the spanwise circulation in the spanwise circulation distribution. The forward-swept blades did not exhibit any aeroacoustic advantage. The alternately swept configuration as a tandem rotation has the potential for decreasing the sound levels at the blade passage frequencies by the dispersion of sound with neither any sacrifice of aerodynamic performance nor mechanical complexity. Author

**A86-23191*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**A PROPELLER MODEL FOR STUDYING TRACE VELOCITY EFFECTS ON INTERIOR NOISE**

J. R. MAHAN and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 602-608) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 142-147. Previously cited in issue 13, p. 1943, Accession no. A85-30389. refs
(Contract NAG1-493)

**A86-23192#**

**CONTROL OF AEROELASTIC INSTABILITIES THROUGH STIFFNESS CROSS-COUPLING**

T. A. WEISSHAAR (Purdue University, West Lafayette, IN) and R. J. RYAN (Rockwell International Corp., Los Angeles, CA) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA, Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 226-235) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 148-155. Previously cited in issue 13, p. 1914, Accession no. A84-31710. refs

**A86-23252**

**SOCIETY OF FLIGHT TEST ENGINEERS, ANNUAL SYMPOSIUM, 15TH, ST. LOUIS, MO, AUGUST 12-16, 1984, PROCEEDINGS**

Lancaster, CA, Society of Flight Test Engineers, 1984, 196 p. For individual items see A86-23253 to A86-23273, A86-23275.

Various papers on flight test technology are presented. The topics addressed include: airborne instrumentation magnetic tape recording through the early 1990s; automated electromagnetic compatibility testing of naval aircraft and integrated avionics; advanced vibration monitoring approach to engine/airframe health and usage monitoring; use of video cassette recorders for combined video and PCM data recording; IFDAPS: hardware and software overview and a user's view; F-16XL flight test overview; infrared instrumentation capabilities at Eglin Air Force Base. Also discussed are: flight test data acquisition and processing system; state of the art computer graphics systems for flight safety monitoring; improved smoke generator for aircraft testing; telemetry system prototype development; intelligent amplifier; inflight resolution evaluation for thermal imaging systems; flight evaluation of a digital electronic engine control; Air Force flight test instrumentation system; and economical in-flight calibration of air data sensors using inertial navigation units as reference. C.D.

**A86-23254**

**AUTOMATED ELECTROMAGNETIC COMPATIBILITY (EMC) TESTING OF NAVAL AIRCRAFT AND INTEGRATED AVIONICS**

D. E. TETHER (Veda, Inc., Lexington Park, MD) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 2-1 to 2-7.

The Electromagnetic Compatibility (EMC) testing of Naval aircraft and their associated mission systems is chracteristically as complex as the mission systems being tested and consumes most of the EMC engineers time performing repetitive observations. This paper discusses automation of the repetitive sequences of observations contained in Emission Control (EMCON) and Conducted Emission (CONEM) testing of Naval aircraft and their mission systems. The effects of automation on the continuing escalation in cost of EMC testing are addressed. Author

**A86-23260**

**THE F-16XL FLIGHT TEST PROGRAM**

J. N. BOWER and S. R. SCOTT (USAF, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 9-1 to 9-5.

This paper presents an overview of the F-16XL Phase I flight test program recently conducted at the Air Force Flight Test center (AFFTC), Edwards AFB, California. The F-16XL was a straight-forward airframe modification of the existing F-16A designed to enhance range, payload and speed capabilities. By retaining the majority of the already-proven F-16A systems, the technical and flight test risks for the F-16XL were significantly reduced compared to similar prototype development programs. Prior to any program decision, it was necessary to demonstrate that the XL design concept improved the operational characteristics of the F-16A while imposing no adverse effects. This could only be accomplished through an extensive flight test program. Author

**A86-23267**

**RESULTS OF HIGH ANGLE-OF-ATTACK TESTING OF THE F-15 WITH CONFORMAL FUEL TANKS**

M. D. BASS (McDonnell Aircraft Co., St. Louis, MO) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 16-1 to 16-6.

Results of the high angle-of-attack flight characteristics evaluation of the F-15 equipped with Conformal Fuel Tanks are presented. Testing was accomplished as part of USAF Conformal Fuel Tanks Certification. High angle-of-attack feight characteristics were benign, and similar to the high AOA flight characteristics of the F-15 without Conformal Fuel Tanks. The flight test long noseboom caused adverse high angle-of-attack characteristics. Removal of the noseboom eliminated the adverse characteristics. Future high angle-of-attack test programs should verify the requiement for use of this device. Testing was accomplished without a spin parachute installation on the aicraft, and the cautious approach to testing is documented. Author

**A86-23270**

**ECONOMICAL IN-FLIGHT CALIBRATION OF AIR DATA SENSORS USING INERTIAL NAVIGATION UNITS AS REFERENCE**

K.-H. BURGER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 19-1 to 19-10.

An economical method of aircraft sensor calibration, AUTARK, is described. The method makes it possible to obtain reliable estimates of sensor errors using radar altimeter measurements and navigational data. Among the specific aircraft parameters measured by AUTARK are: the angle of attack, sideslip angle, and fuselage bending due to air loads. The method was evaluated during recent calibrations tests on the Tornado combat aircraft. It is found that the AUTARK method reduced the number of flying hours required to calibrate aircraft sensors. I.H.

**A86-23271**

### THE ROLE OF THE FLIGHT TEST DEPARTMENT IN THE DEVELOPMENT OF NEW TECHNOLOGY AIRCRAFT

A. J. PUGLIESE (Grumman Aerospace Corp., Bethpage, NY) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 20-1 to 20-8.

In the present discussion of advanced aerodynamic and structural concepts under development, the relationship of developmental experience to the preparation of highly relevant and through, full scale test program is noted and attention is given to multimode flight control system testing and the development of flight test procedures for the analysis and correcting of system failures in flight. The need for instant and reliable emergency power in relaxed stability fly-by-wire aircraft requires through preflight testing and flight planning. The conclusions presently reached concern the management objectives of future flight test programs, regarding the lead time and preparatory measures required for new aircraft. O.C.

**A86-23508**

### ENVIRONMENTAL CONTROL SYSTEM SIMULATION USING EASY5, AS APPLIED TO THE F-14

G. L. HOFFMAN (U.S. Navy, Naval Air Development Center, Warminster, PA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 8 p.
(SAE PAPER 851318)

The Naval Air Development Center has developed a thermal model of the F-14 Environmental Control System (ECS) using the EASY5 dynamic analysis computer program. In addition to discussing the modeling effort, this paper also details several improvements made to the EASY5 program in an attempt to improve its accuracy, flexibility, and computational stability. Also highlighted is a simplified version of the F-14 EASY5 ECS model which is being used to conduct trade studies and to calculate the initial conditions required to run the EASY5 program. Author

**A86-23509**

### DIGITAL CONTROLLED CLOSED LOOP AIR CYCLE DEVELOPMENT

G. S. TSUJIKAWA (Boeing Military Airplane Co., Seattle, WA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 12 p.
(SAE PAPER 851319)

The use of a closed loop environmental control system (ECS) in military aircraft incorporating microprocessor control can reduce engine energy extraction requirements, yielding a reduction in aircraft weight penaltites and/or an increase in range. In addition, chemical and biological warfare threats are reduced and a more favorable thermal environment is obtained for electronics. Attention is presently given to the development of an ECS digital control system whose capabilities have been demonstrated in a laboratory breadboard test rig. O.C.

**A86-23510**

### THE NEW ENVIRONMENTAL CONTROL SYSTEM FOR THE B-52 G/H AIRCRAFT

F. L. BUSCARELLO (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 14 p.
(SAE PAPER 851320)

Environmental Control System (ECS) for the B-52 G/H Aircraft The Boeing B-52 G/H aircraft uses precooled engine bleed air as a source for cabin pressurization and cabin, missile and avionics air conditioning. These systems are controlled by two solid state controllers which also contain built in self test and fault isolation. The ECS regulates the bleed air pressure and flow via an electrical signal from a cooling effect sensor in the avionics air supply. This flow control approach saves engine bleed air by not dumping excessive cold air into the avionics equipment and not overcooling or overheating the two cabins or missiles. The missile conditioning system mixes cold and warm air to keep the missiles at the required temperature. The system also provides a 'go-no-go' signal to the cabin to indicate 'temperature readiness' of the missiles. The two cabins are separately temperature controlled through individual temperature selectors and controls. Author

**A86-23511**

### LOW COST THERMAL CONTROL FOR FLIGHT TEST LASER RADAR

A. BRUNS (McDonnell Douglas Astronautics Co., St. Louis, Mo) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 11 p.
(SAE PAPER 851321)

As part of an internal program to develop laser radar guidance systems for advanced cruise missiles, a thermal control unit (TCU) was developed for captive flight testing. Requirements of low cost, low maintenance, and small size resulted in the choice of an active, closed-loop, liquid TCU that uses ram air as the heat source or sink. Four coldplates thermally couple the laser to the TCU in the pump-operated liquid cooling reservoir. Four thermoelectric heat pumps mounted on a finned heat sink transfer heat between the liquid loop and the ram air. Temperature sensors downstream of the laser determine the amount of amplifier current driving the thermoelectrics, and whether they should add heat to the coolant or remove it. In flight tests on a King Air aircraft it successfully maintained the laser at + or - 1 C within the operating limits of 27-38 C over all air and ground conditions with a laser heat dissipation load of 200 watts on a 43 C hot day. Performance characteristics of the heating and cooling modes are presented. R.R.

**A86-23545**

### COMPUTER CONTROLLED VARIABLE PRESSURE REDUCING/SHUT-OFF VALVE FOR AIRCRAFT ECS

M. ANDRIANO, V. MARCHIS (Torino, Politecnico, Turin, Italy), and A. MANNINI (Microtecnica-Torino, Turin, Italy) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p.
(SAE PAPER 851360)

The present paper reports the development results of a computer controlled variable setting pressure reducing valve (VPRV) designed by Microtecnica and suitable for operation in the latest generation of aircraft ECS. The valves features a double element design, allowing a total independent operation (Shut-Off section and pressure reducing section) offering thereby high reliability and safety. The valve provides wide capability of varying the pressure set point by action of an electric servo and allows considerable weight and energy saving in the ECS design. Results of Experimental Tests performed in the development program are presented in detail. Author

**A86-23757**

### A POSSIBLE APPROACH TO THE DIAGNOSTICS OF THE HYDRAULIC SERVOMECHANISM OF THE AIRCRAFT CONTROL SYSTEM [MOZNY PRISTUP K DIAGNOSTIKOVANIU HYDRAULICKEHO SERVOMECHANIZMU RIADENIA LIETADLA]

A. ZIGO Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 185-189. In Slovak.

An approach to the analysis of the performance of the hydraulic servomechanism of the aircraft control system is presented. The approach involves a systematic mathematical analysis of the dynamic characteristics of the individual elements of the hydraulic control system and determination of the intermediate values of certain parameters essential for the reliable operation of the system. The results of the analysis are then used, together with flight operation data, to construct a topological model which provides a way to determine an optimum set of diagnostic parameters characterizing the technical condition of the system. V.L.

**A86-23767**

**LOCATING AND DEMAGNETIZING MAGNETIZED AIRCRAFT COMPONENTS FOLLOWING A LIGHTNING STROKE [LOKALIZACE ZMAGNETOVANYCH CASTI LETADEL PO UDERU BLESKU A JEJICH ODMAGNETOVANI]**

J. HRABAK and K. DRAXLER Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 263-265. In Czech.

The physical mechanisms underlying the magnetization of aircraft components affected by a lightning stroke are examined, and methods are presented for locating and demagnetizing such components. A system for locating and demagnetizing lightning-affected parts and components is briefly described. V.L.

**A86-23768**

**METHODS FOR DETERMINING THE WEIGHT AND THE CENTER OF GRAVITY OF AIRCRAFT - THE PLATFORM BALANCE OF THE AERONAUTICAL RESEARCH AND TEST INSTITUTE [ZPUSOBY URCOVANI HMOTNOSTI A POLOHY TEZISTE LETADEL, PLOSINOVE VAHY VZLU]**

J. LUKAS and J. VIDIECAN Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 267-273. In Czech. refs

The various methods for determining the weight and the center of gravity of aircraft are reviewed with reference to their relative advantages and shortcomings. The platform balance developed by the Aeronautical Research and Test Institute is then described in detail, with attention given to its mechanical and electrical systems, functions, and methods of electrical signal processing. V.L.

**A86-23769**

**A STUDY OF THE SERVICE LIFE OF FAIL-SAFE AIRFRAME STRUCTURES ON THE BASIS OF ROUTINE INSPECTIONS AND CRACK SIZE ASSESSMENT [SLEDOVANI ZIVOTA DRAKU KONSTRUKCI BEZPECNYCH I PRI PORUSE NA ZAKLADE PROHLIDEK A POSUZOVANI VELIKOSTI TRHLIN V PROVOZU]**

V. KAHANEK Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 275-279. In Czech.

Problems associated with the estimation of the service life of the main airframe structure designed for a safe service life or for fail-safe operation are examined, with particular attention given to the differences between the two design philosophies. While in the former case, only the operating conditions of the aircraft are monitored, in the latter case an aircraft can be taken out of service on the basis of the extent of fatigue damage. V.L.

**A86-23799**

**THE A320 WING - DESIGNING FOR COMMERCIAL SUCCESS**

R. F. BACK and J. R. WEDDERSPOON (British Aerospace, Weybridge, England) Aerospace (ISSN 0305-0831), vol. 13, Jan. 1986, p. 12-19.

The development of the wing for the new European aircraft through the collaboration of various European aircraft companies, is examined. The aerodynamic and engineering optimization testing of numerous wing designs to produce a minimum fuel burning aircraft which is easily manufactured, and operational efficient is analyzed. The designing and testing of a high lift system, which included studying leading and trailing edge devices and flap track systems, is described. The high lift system selected for the aircraft is a near full span leading edge over-wing slat with a trailing edge single-slotted flap system across the span, and an underslung beam track system. I.F.

**A86-24731#**

**AEROELASTIC OSCILLATIONS CAUSED BY TRANSITIONAL BOUNDARY LAYERS AND THEIR ATTENUATION**

D. G. MABEY, P. R. ASHILL, and B. L. WELSH (Royal Aircraft Establishment, Aerodynamics Dept., Bedford, England) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 49-56. refs

(AIAA PAPER 86-0736)

Recent wind tunnel tests on model wings show large amplitude aeroelastic oscillations in the first bending mode associated with transitional boundary layers. A possible mechanism is suggested, which explains the oscillations primarily in terms of reduced aerodynamic damping. The validity of the hypothesis is confirmed by further measurements, in which the oscillations were attenuated by the installation of a vibration absorber in the hollow wing-tip body. Aeroelastic oscillations caused by transition have implications for the measurement of forces, buffeting and flutter characteristics in wind tunnels (including cryogenic facilities), and for the operation of laminar-flow aircraft. Author

**A86-24759*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HOVER IN-GROUND-EFFECT TESTING OF A FULL-SCALE, TILT-NACELLE V/STOL MODEL**

J. E. ESHLEMAN, M. R. DUDLEY (NASA, Ames Research Center, Moffett Field, CA), and C. J. SCHELL (Grumman Aerospace Corp., Bethpage, NY) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 346-360. refs

(AIAA PAPER 86-0780)

A full-scale, tilt-nacelle V/STOL aircraft model was tested in hover at the National Full Scale Aerodynamics Complex (NFAC), NASA Ames Research Center. The model was powered by two TF-34 turbofan engines. It was tested at several ground heights and control deflections. Test technique and test setup were documented. Limited results show that (1) a small change in control power with ground height was measured, and control power was found to be good over + or - 20 deg of horizontal vane deflection; (2) integrated fuselage undersurface pressures, when compared with the total model loads and measured thrust, defined the effect of the fountain and its related flow field on model forces and moments; and (3) there was no indication of hot gas ingestion during simulated takeoff in calm winds from wheels on deck ground height. Author

**A86-24988**

**ONE MAN AND 3,000 MILLION OPERATIONS A SECOND - PREPARING FOR THE LHX COCKPIT**

M. LAMBERT Interavia (ISSN 0020-5168), vol. 41, Jan. 1986, p. 27-30.

With the use of the Advanced Rotorcraft Technology Integrator (ARTI), an equipment system is being developed for the mid-1990's for the LHX helicopter to enable single pilot operation of all eight of its scout and attack missions. The system must be capable of executing 3,231 million operations/sec covering navigation, communication, electronic defensive measures, displays, interfaces, target recognition and weapon delivery. If it becomes available, Very High-Speed Integrated Circuitry will make possible a system design of relatively low weight (54 kg), volume, and cost. The system necessitates helicopter design changes to simplify handling, such removal of cross coupling between the axes of control, and creating an optimum combination of side-stick and rudder pedal control. A computer-based Cockpit Emergency Directed Action Program could be used to detect and take action on system faults. Information will have to be circulated over multiple electronic and optical data buses. R.R.

**A86-24989**

**THE HELICOPTER AND THE OTHER VTOL DESIGNS - AN INTERAVIA READER'S MANUAL**

N. LAPPOS (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) Interavia (ISSN 0020-5168), vol. 41, Jan. 1986, p. 33-35.

The helicopter's future development and competitiveness with the VTOL are considered. Potential developments in thermodynamic power resulting in the reduction of engine weight will most likely increase safety and maneuverability rather than payload (as already evidenced by the S-70 Black Hawk). The increased use of microelectronics will increase cost efficiency in both design and performance. Advances in rotor technology will have to balance rotor offset and control response with vibration damping. Low-drag helicopters such as the Sikorsky S-76 with cruise speeds of over 180 kn are the model for maximum achievable velocity, while improvements in anti-torque system for tail rotor design will probably achieve sideways speeds of 35 kn. VTOL's such as the tilt-rotor have higher disk loading than the helicopter, and they trade-off higher speed and range against lower hover payload fraction and much larger powerplant weight/power requirements. Other developments including the Sikorsky ABC (using coaxial counter-rotation rotors), and the NASA/Sikorsky X-Wing (with a slotted oval blade-spar cross-section), will not affect the helicopter's projected dominance in payload/trip time/cost for ranges of up to 300 km. R.R.

**A86-24990**

**LAVI - ADVANCED FIGHTER AND INDUSTRIAL SPRINGBOARD**

B. WANSTALL Interavia (ISSN 0020-5168), vol. 41, Jan. 1986, p. 77-79, 82, 83.

The estimated $2,200 million program for the development of Israel's Lavi, the first all-CAD/CAM combat aircraft, and its impact on Israeli industry, is discussed. Design choices were dictated by lowest life-cycle costs and the Israeli Air Force requirements for overall aircraft capability in terms of performance, survivability (requiring low radar, IR and visual signatures, built-in passive and active ECM and decoy missiles backed up by Shafrir air-to-air missiles), and sortie generation rate. Operational requirements determined a wing configuration of all-moving canards and a quadruplex digital fly-by-wire control system with full artificial stability. Systems requirements were flexibility and adaptability to upgrading, and avionics used MIL-STD-175OA computers. Four two-seater and two single-seater prototypes are scheduled for test flighting beginning in mid-1986. The U.S. has contributed significant funding for the project and will benefit by substantial subcontracting. Aircraft specifications are included. R.R.

**A86-25020**

**D-CALM - NEW RESEARCH AIRCRAFT FOR REMOTE SENSING [D-CALM - NEUES FORSCHUNGSFLUGZEUG FUER DIE FERNERKUNDUNG]**

F. SCHATT (DFVLR, Oberpfaffenhofen, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 39, 40. In German.

The 'Department Flight Operations' of the DFVLR received the new research aircraft 'D-CALM' on August 20, 1985. The aircraft is to be employed in operations related to remote-sensing studies conducted by the DFVLR. During the period from 1975 to 1977, the DFVLR has participated, for the first time, in an operational earth reconnaissance project. It was found, that future tasks would require the use of a larger aircraft than the one employed in the first project. In the context of this conclusion, the D-CALM was obtained. The reasons for the selection of the particular type of aircraft chosen are discussed along with a number of modifications which were needed in connection with the functions of the D-CALM as research aircraft. Attention is given to the advantages of the turboprop engines of the new aircraft, the suitability of the aircraft for operations related to oceanography and studies involving flights over extended desert areas, the utilization of a 'wing of new technology' the cabin, the navigation system, and the first operation. G.R.

**A86-25024**

**COMPUTER-AIDED 'SOMATOGRAPHY' FOR THE ERGONOMIC DESIGN OF THE ATTAS EXPERIMENTAL COCKPIT [RECHNERGESTUETZTE SOMATOGRAPHIE ZUR ERGONOMISCHEN GESTALTUNG DES ATTAS-EXPERIMENTALCOCKPITS]**

R. UCKERMANN and K. KROHN (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 62, 63. In German.

The Advanced Technologies Testing Aircraft System (ATTAS) was obtained by installing suitable equipment on a VFW 614 aircraft, taking into account also appropriate alterations and modifications with respect to the original aircraft structure. ATTAS is to provide a basis for studies of the feasibility of an employment of the most advanced technologies in aircraft. In this context, an experimental cockpit is to be established in ATTAS. In connection with the design of this cockpit, studies involving computer-aided 'somatography' are conducted. According to Jenik and Jenik (1975), 'somatography' is a graphic-constructive method for the representation of schematic pictures of the human figure in significant postures. The objective of the considered approach is the adaptation of the cockpit to the human figure. Attention is given to the functional characteristics of somatography, and the application of these characteristics to the design of the experimental cockpit. G.R.

**A86-25089**

**ROTORCRAFT TRENDS. II - REQUIREMENTS AND MONITORING**

T. FORD Aircraft Engineering (ISSN 0002-2667), vol. 57, Dec. 1985, p. 6-9, 12.

The use of health monitoring for damage detection in helicopters and to achieve better airworthiness is examined. The importance of visual inspection aids, vibration analysis, and wear debris monitoring in the monitoring process is discussed. The health monitoring requirements for the components of the transmissions, rotor systems, flight control systems, structure, and engines and fuel systems are described. The applications of vibration signal averaging, full flow chip detector, spectrometric oil analysis, ferrographic oil analysis, and introscope inspection to health and usage monitoring of helicopters are investigated, and examples are provded. Author

**A86-25095#**

**COMPARATIVE ANALYSIS OF TWO METHODS FOR EVALUATING THE LOADS ACTING ON THE TAIL PLANE DURING A SYMMETRIC MANOEUVRE**

J. BOJANOWSKI and W. LESNIEWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 100, 1985, p. 3-31. In Polish. refs

The two methods which are compared are those for evaluating the loads acting on the tail plane during a pitching maneuver. The first method is based on the assumed changes of the load factor as a function of time and the other method is based on the assumed changes of the elevator displacement. An equation of short-duration motion is derived with a minimum number of assumptions. The procedure for obtaining the relations used in both cases is presented as well as formulas for computing the loads acting on the tail plane. This computation is performed for a particular type of aircraft over a wide range of altitude and flying speed. The results are presented in a graphical form. Some inferences are drawn as regards the extremum values of the loads acting on the tail plane as obtained by both methods. Author

**A86-25096#**

**AN ANALYSIS OF THE INFLUENCE OF THE DURATION AND SHARPNESS OF A SYMMETRIC MANOEUVRE ON THE LOAD ACTING ON THE TAIL PLANE**

J. LAMPARSKI and M. GRABIAS Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 100, 1985, p. 33-47. In Polish.

The load acting on the tail plane during a symmetric maneuver is analyzed for various aircraft types on the basis of the familiar equation of the longitudinal motion of an aircraft given in the NACA Report 1007. The influence of the time in which the maximum load is attained and of the sharpness of the maneuver on the forces acting on the tail plane is studied. The analysis is performed for each of the aircraft types considered, their centers of gravity being assumed to be located in the middle position. An additional analysis is made for one of them for three locations of the center of gravity. Some conclusions are drawn concerning the influence of the parameters assumed on the forces acting on the tail plane. Author

**A86-25180#**

**EFFECT OF SWEEP ANGLE ON STATIC AEROELASTICITY - THEORY FOR PHYSICAL MEANINGS**

S. ANDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 372, 1985, p. 45-49. In Japanese, with abstract in English. refs

A theory is presented to show simply the essential effect of sweep angle on divergence and aileron reversal. For this purpose, several simplification assumptions are introduced such as high aspect ratio, strip theory of aerodynamics, effective wing root and tip, assumed mode shapes for bending and torsion, etc. Thus, a kind of theory for 'typical section' is developed. The result shows that the divergence speed would be increased and decreased by sweep back and forward, respectively, as is well known. But for aileron reversal, the results seems not to agree with the textbook description. The result obtained here suggests that the reversal speed increases irrespective of sweep back or forward, while the lift due to aileron angle increases and decreases for sweep forward and back, respectively. Author

**A86-25188#**

**ENERGY SAVING IN AIRCRAFT**

H. KIMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 374, 1985, p. 138-146. In Japanese.

Current status and historical evolution of energy saving systems in aircraft are reviewed. The factors affecting the fuel mileage of aircraft, a method of energy saving, advantages of the turbofan engine for saving fuel cost, and performance characteristics of the fourth generation jet aircraft (Boeing 767) in energy saving are analyzed. The development of the propfan for reducing the fuel cost is emphasized. The contributing factors in reducing the fuel consumption are listed. S.H.

**A86-25237#**

**FIGURES OF OUT SURFACE OF AN AIRPLANE MODEL**

M. NAKAMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 381, 1985, p. 607-612. In Japanese, with abstract in English. refs

Computational figures of airplane surface are made to match an airplane shape in the sense of sight. The airplane surface is described with a large number of quadrangles which are based on section lines of the airplane. In one concrete example, the section lines of an airplane model are measured. This airplane model is composed of a body, a wing, a tail unit, and two jet engine nacelles. Several figures of the airplane model from various points of view are drawn by using the law of perspective. These figures give clear information of the shape of the airplane model. Author

**A86-25423**

**OPTIMAL LIFTING SURFACES OF WINGS OF COMPLEX CONFIGURATIONS AT SUPERSONIC FLIGHT VELOCITIES [OPTIMAL'NYE NESUSHCHIE POVERKHNOSTI KRYL'EV SLOZHNOI GEOMETRII PRI SVERKHZVUKOVYKH SKOROSTIAKH POLETA]**

E. M. PROKHOROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1985, p. 154-160. In Russian. refs

The problem of flow past infinitely thin wings, producing only slight perturbations in an ideal gas, is analyzed using a linear formulation. The optimum shape of the wing is determined by finding a function of the local angles of attack which corresponds to a minimum drag coefficient under constraints on the lifting force coefficient and the pitching moment. For a given Mach number, nonseparated flow is realized on an optimal wing, with a zero load on the subsonic leading edge. V.L.

**A86-25848**

**SUPERSONIC PASSENGER DECADE**

J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 129, Jan. 25, 1986, p. 20-25.

The components of the French and British Concordes are described. The fly-by-wire controls of the powered flying control unit, and the nozzles, reheat, and thrust-reversers of the Olympus engines are examined. The problems encountered with the undercarriage are analyzed. The monitoring and maintenance of the aircraft to ensure an adequate service life are investigated. The Concorde's fuel-burn curve and noise level are discussed. I.F.

**A86-25925#**

**STRUCTURAL AIRWORTHINESS - A DECADE OF DEVELOPMENTS**

J. W. BRISTOW (Civil Aviation Authority, London, England) (International Federation of Airworthiness, Conference, Amsterdam, Netherlands, Nov. 1985) Tech Air (ISSN 0040-0831), vol. 44, Feb. 1986, p. 1-9. refs

The development of airworthiness standards which will maintain the structural integrity of aircraft and helicopters is discussed. The fail safe and structural integrity audit procedures for monitoring aging aircraft are examined. The use of SN curves and load spectra for fatigue/damage tolerance requirements for helicopter designs is analyzed. The present methods of testing composites and the establishment of working rquirements for the structural design and processing of composite materials are investigated. I.F.

**A86-26103#**

**IMPROVEMENT OF TWO BLADE SECTIONS FOR HELICOPTER ROTORS**

K. H. HORSTMANN, H. KOESTER (DFVLR, Brunswick, West Germany), and G. POLZ (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 14 p. refs

Attention is given to recently developed advanced airfoils for helicopter rotor blades which have been subjected to theoretical and experimental investigations with a view to performance refinement. Near-root airfoil lift coefficients at low Mach numbers and tip airfoil drag rise numbers have both been increased in this fashion. Performance comparisons are made between the present, improved airfoils and their original form, as well as with the classic NACA 23012 profile. O.C.

**A86-26104**

**AN EXPERIMENTAL INVESTIGATION OF THE INFLUENCE OF A RANGE OF AEROFOIL DESIGN FEATURES ON DYNAMIC STALL ONSET**

P. G. WILBY (Royal Aircraft Establishment, Farnborough, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p. refs

Data from oscillatory pitch tests are used to evaluate the maximum value of incidence that can be attained without incurring stall during the cycle. It is deduced that, for the 12-percent thick airfoils, when stall is first encountered (as mean incidence is increased), stall is triggered by a rear separation. Data from tests at constant pitch rate are then examined, and it is seen that, at low pitch rates, stall is triggered by a rear separation for the thicker airfoils. However, the rear separation is progressively suppressed as pitch rate increases, allowing a greater incidence to be attained before stall occurs, until eventually leading edge separation provides the trigger. For an 8 percent thick airfoil, stall is triggered by a leading edge separation under all conditions. Author

**A86-26105*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**APPLICATIONS OF AN ANALYSIS OF AXISYMMETRIC BODY EFFECTS ON ROTOR PERFORMANCE AND LOADS**

W. JOHNSON and G. K. YAMAUCHI (NASA, Ames Research Center, Moffett Field, CA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 23 p. refs

A computationally efficient body analysis is developed and coupled with a comprehensive helicopter analysis to calculate the body-induced aerodynamic effects on rotor performance and loads. A modified slender body theory is used as the body model. With the objective of demonstrating the accuracy, efficiency, and application of the method, the analysis at this stage is restricted to axisymmetric bodies at zero angle of attack. By comparing with results from an exact analysis for simple body shapes, it is found that the modified slender body theory provides an accurate potential flow solution for moderately thick bodies, with only a 10-20 percent increase in computational effort over that of an isolated rotor analysis. The computational ease of this method provides a means for routine assessment of body-induced effects on a rotor. Results are given for several configurations that typify those being used in the NASA Ames 40 x 80-ft Wind Tunnel and in the rotor-body interference tests being conducted at NASA Ames. Author

**A86-26113*#** Massachusetts Inst. of Tech., Cambridge.

**A THEORETICAL ANALYSIS OF THE EFFECT OF THRUST-RELATED TURBULENCE DISTORTION ON HELICOPTER ROTOR LOW-FREQUENCY BROADBAND NOISE**

M. WILLIAMS and W. L. HARRIS (MIT, Cambridge, MA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 14 p. refs
(Contract NSG-1583)

The purpose of the analysis is to determine if inflow turbulence distortion may be a cause of experimentally observed changes in sound pressure levels when the rotor mean loading is varied. The effect of helicopter rotor mean aerodynamics on inflow turbulence is studied within the framework of the turbulence rapid distortion theory developed by Pearson (1959) and Deissler (1961). The distorted inflow turbulence is related to the resultant noise by conventional broadband noise theory. A comparison of the distortion model with experimental data shows that the theoretical model is unable to totally explain observed increases in model rotor sound pressures with increased rotor mean thrust. Comparison of full scale rotor data with the theoretical model shows that a shear-type distortion may explain decreasing sound pressure levels with increasing thrust. Author

**A86-26115#**

**PREDICTION OF AUDITORY MASKING IN HELICOPTER NOISE**

G. M. ROOD (Royal Aircraft Establishment, Human Engineering Div., Farnborough, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p. refs

A research program was initiated with the objective to predict to a degree of accuracy the masked thresholds of listeners under high noise conditions. Existing models were extended and modified to cover aspects of military operations both in helicopters and fixed wing aircraft. The present paper provides a description of research regarding the application of the auditory model, giving attention to the conclusions of the research with respect to real-life helicopter noise and operational conditions. A basic auditory filter model was used in the determination of the masked auditory threshold from experiments carried out in the helicopter noise simulator. The basis of the conducted experiment was to measure the auditory threshold of a number of subjects to a range of pure tone frequencies whilst exposing the subjects in the helicopter noise simulator to 'real-life' noise conditions. G.R.

**A86-26116#**

**DESIGN OF THE 225-KNOT CONVENTIONAL ROTOR**

F. J. MCHUGH (Boeing Vertol Co., Philadelphia, PA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 25 p. refs

A study on the baseline definition of the advanced flight research rotor (AFRR) of 225 km maximum efficiency cruise speed, and a few details on sensitivity study results and the preliminary design, are presented. The study ground rules were for a four-blade rotor with drag loading of 1500 lb/sq ft, an advancing-tip Mach number limit of 0.9, disk loading of 6.25 lb/sq ft, and Mangler 1 loading. The airfoils were operated at maximum lift to drag. Recommendations include: thrust weighting to define the blade chord; a blade planform with an inverse taper to 88 percent and conventional taper to the tip to provide the maximum rotor lift to equivalent drag (L/DE); and inboard blade stiffness out to 60 percent to reduce the twist requirement. Furthermore, the elastic twist is basically first and second harmonic with a very small amount of third harmonic, and it is mandatory to match the optimum pitch on the advancing side of the rotor to maximize performance. The recommended blade with a L/De of 9.1 shows a 60 percent improvement from the CH-46E reference rotor, and its development has been determined to be feasible. R.R.

**A86-26117#**

**ROTORCRAFT STRUCTURAL DYNAMIC DESIGN MODIFICATIONS**

S. V. HANAGUD, M. MEYYAPPA, Y. P. CHENG, and J. I. CRAIG (Georgia Institute of Technology, Atlanta) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 14 p. refs
(Contract DAAC29-82-K-0094)

At present, most of the structural dynamic design modifications are being done primarily by the use of analytical finite element modelling techniques. Design verifications and testing are accomplished by tests on the full scale rotorcraft with and without modifications. This limits the options for such design modifications. The responsibility primarily lies on the analytical modelling capability. In this paper, a different approach that complements the analytical modelling has been suggested. This approach is by the use of structural dynamic physical scale models, optimization techniques with frequency constraints and general structural dynamic system identification techniques. Author

**A86-26119#**

**INVESTIGATION ON A SMALL SCALE MODEL OF DUCTED COMPOSITE COUNTERROTATING ROTOR**

D. DINI (Pisa, Universita, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 10 p.

A design feature and prospective performance study is conducted for a novel helicopter configuration in which counterrotating, high solidity rotors are located fore and aft above the fuselage within small diameter ducts. Experimental data obtained with small scale models indicate sufficient dynamic stability in forward flight and maneuvering, on the basis of separate use of the rotors and auxiliary jet power. Increased aerodynamic drag due to the rotor duct limits forward speed, however, so that variable geometry stator vanes under the rotors are required for the generation of lifting flow. O.C.

**A86-26120*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**APPLICATIONS OF NUMERICAL OPTIMIZATION METHODS TO HELICOPTER DESIGN PROBLEMS - A SURVEY**

H. MIURA (NASA, Ames Research Center, Moffett Field, CA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 22 p. Previously announced in STAR as N85-10036. refs

A survey of applications of mathematical programming methods is used to improve the design of helicopters and their components. Applications of multivariable search techniques in the finite dimensional space are considered. Five categories of helicopter design problems are considered: (1) conceptual and preliminary design, (2) rotor-system design, (3) airframe structures design, (4) control system design, and (5) flight trajectory planning. Key technical progress in numerical optimization methods relevant to rotorcraft applications are summarized. M.A.C.

**A86-26123#**

**OPTIMUM HELICOPTER IN THE FLIGHT SPECTRUM**

A. RUSSO, G. BONAITA, M. CRESPI, and S. PANCOTTI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 22 p. refs

Attention is given to an optimization technique for helicopter design that encompasses all fundamental parameters of the vehicle; the energy function used allows an averaging of design features, among different anticipated flight conditions for the given performance spectrum or mission profile, with the desired level of importance. For multimission or multi-flight spectrum cases, there exist many optimization strategies based on a pseudoenergy function. Attention is presently given to redundancies among the elements to be optimized, and to elements that significantly reduce total energy. Design differences between conventionally defined and optimized helicopters are noted. O.C.

**A86-26124#**

**THE PROJECT FOR ANTI-TANK HELICOPTER**

G. BOLOGNA and A. GIOVANNINI (Agusta S.p.A., Milan, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 25 p.

The performance, low detectability, high survivability and weapons platform effectiveness criteria that were used in the design optimization of the dedicated antitank A-129 helicopter are discussed, in the context of the most probable NATO battle scenarios. The design of a multirole helicopter that could be adapted for antitank use by means of a kit was rejected in favor of an antitank weapons platform; iterative tradeoff studies resulted in an exceptionally small and light aircraft extensively using primary structure composites. The effects of missile and small arms threats to such a helicopter are discussed from the viewpoints of powerplant, transmission, rotor, flight control system, and other vulnerabilities. Armor and crashworthiness design considerations are also noted. O.C.

**A86-26126#**

**IMPACT OF ADVANCED TECHNOLOGY ON FUTURE HELICOPTER PRELIMINARY DESIGN**

J. P. ROGERS, R. A. SHINN, and R. L. SMITH (U.S. Army, Directorate for Advanced Systems, St. Louis, MO) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 16 p.

The impact of advanced technology on size and weight of future helicopters was investigated by conducting preliminary design studies for a conventional helicopter configuration designed with 1970's technology, and again with predicted near-term advanced technology levels. The advanced technologies considered in the study include composite structures, advanced engines, digital/optical flight controls, advanced weaponry, and advanced rotor technology. The predicted effect of these advanced technologies on future helicopter rotor performance, airframe weight, installed power, and subsystems weight is presented, as are trends of engine and vehicle sizing with drag reductions. Finally, the integrated effect of across-the-board application of advanced technology on future helicopter preliminary design sizing is presented. The results demonstrate the significant reductions in airframe and engine size and weight that advanced technology will provide for future rotorcraft concepts. Author

**A86-26138#**

**FEASIBILITY OF SIMPLIFYING COUPLED LAG-FLAP-TORSIONAL MODELS FOR ROTOR BLADE STABILITY IN FORWARD FLIGHT**

G. R. NILAKANTAN (Hindustan Aeronautics, Ltd., Bangalore, India) and G. H. GAONKAR (Indian Institute of Science, Bangalore, India) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 32 p. refs

Feasibility of simplifying coupled lag-flap-torsional models is explored for the low-frequency stability of isolated hingeless rotor blades in forward flight. The non-linear equations of moderate deflections with appropriate geometric nonlinearities are valid to third order, so are the perturbed linear equations about time dependent equilibrium (trim) positions. Aerodynamic strip theory based on a quasisteady approximation of two-dimensional unsteady airfoil theory is used. Under linear and quasilinear propulsive trim conditions, stability is investigated for four cases: a base-line model with elastic lag bending, flap bending and torsion degrees of freedom, the modified elastic lag-flap model that neglects only torsional dynamic effects, and the rigid blade models with and without quasisteady approximation to torsion. The method of equivalent Lock number and drag coefficient is used for qualitative insights into dynamic inflow effects. The range of validity of the modified elastic lag-flap and rigid lag-flap models is outlined with respect to torsional frequencies for soft (including matched stiffness) and stiff inplane rotors. Author

**A86-26139#**

**A NONLINEAR MODEL OF AEROELASTIC BEHAVIOUR OF ROTOR BLADES IN FORWARD FLIGHT**

A. ROSEN and O. RAND (Technion - Israel Institute of Technology, Haifa) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 20 p. refs

The paper presents a nonlinear model of the aeroelastic behavior of rotor blades. This model is based on two submodels. The first one is a nonlinear structural/dynamic model while the second is a prescribed-wake unsteady aerodynamic model. The paper concentrates on the method of combining these two submodels. Since these submodels are nonlinear and the steady state is of nonlinear periodic nature, there are certain difficulties in obtaining the final complete aeroelastic response. The paper presents the iterative interactive approach which has been developed and discusses the different problems associated with this model. Two examples are presented where the theoretical results are compared with existing experimental results. It is shown that good agreement is obtained in most of the cases. Author

**A86-26141*#** California Univ., Los Angeles.

**AEROMECHANICAL STABILITY ANALYSIS OF A MULTIROTOR VEHICLE WITH APPLICATION TO HYBRID HEAVY LIFT HELICOPTER DYNAMICS**

C. VENKATESAN and P. P. FRIEDMANN (California, University, Los Angeles) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 27 p. refs

(Contract NAG2-116)

The Hybrid Heavy Lift Helicopter (HHLH) is a potential candidate vehicle aimed at providing heavy lift capability at low cost. This vehicle consists of a buoyant envelope attached to a supporting structure. Four rotor systems are also attached to the supporting structure. Nonlinear equations of motion capable of modeling the dynamics of this multi-rotor/support frame/vehicle system have been developed and used to study the fundamental aeromechanical stability characteristics of this class of vehicles. The mechanism of coupling between the blades, supporting structure and rigid body modes is identified and the effect of buoyancy ratio (buoyant lift/total weight) on the vehicle dynamics is studied. It is shown that dynamics effects have a major role in the design of such vehicles. The analytical model developed is also useful for studying the aeromechanical stability of single rotor and tandem rotor coupled rotor/fuselage systems. Author

**A86-26142#**

### ANALYTICAL AND EXPERIMENTAL RESULTS OF THE GROUND RESONANCE PHENOMENON FOR A.129

ORLANDI, A. CERIOTTI, A. RUSSO, MARCHESE, MAINO (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) et al. Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 37 p. refs

The paper presents the methodology used in AGUSTA to investigate the Ground Resonance problem. The following three phases of the methodology are considered: design definition, analytical/experimental stage, and ground resonance tests. Emphasis is placed on the second phase, with a description given of the ground vibration tests and their results for the experimental part, the two computer codes used with results, and comparisons between them for the analytical part. For the third phase, the initial results of ground resonance tests are shown, and the procedure for the analysis of the signals obtained from these tests is described. All the results and the data of the work refer to the new AGUSTA 129, so they are not complete as the helicopter is still in the prototype phase. Author

**A86-26143#**

### NONLINEAR ANALYSIS FOR DYNAMIC BEHAVIOURS OF A COUPLED ROTATIONAL VIBRATION SYSTEM NEAR ITS CRITICAL SPEED

T. NAGASHIMA and Y. KATO (Defense Academy, Yokosuka, Japan) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p. refs

From a viewpoint of the nonlinear mechanics, theoretical analyses for dynamic behaviors of an unbalanced rotor near its critical speed are carried out, with emphasis on the variation of rotor speed. A numerical method to construct solutions of autonomous, nonlinear, two-degrees-of-freedom differential equations as trajectories upon the reduced phase plane is proposed. It is understood that basic features of dynamic behaviors near the critical speed should be attributed to properties of pumping phenomena, the relaxational energy transformation between rotational and translational motions. Periodic solutions existing in this nonlinear system are determined numerically by the single and the multiple closed trajectories which could be referred as the specified space filling curves in ergodic space. Analytical approaches utilizing the Fourier expansion method are also presented and dependencies of periodic solutions on their initial conditions as well as the nonlinearity parameter are clarified. The existence of another kind of periodic solutions is suggested with relation to the diverged trajectories where the rotational motion of unbalanced rotor is degenerated to the reciprocating one. Author

**A86-26144*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### HOVER TEST OF A FULL-SCALE HINGELESS ROTOR

W. WARMBRODT and R. L. PETERSON (NASA, Ames Research Center, Moffett Field, CA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 24 p. Previously announced in STAR as N84-33401. refs

The performance and aeroelastic stability in hover of a 9.8-m diameter, hingeless helicopter rotor system was evaluated. Rotor performance and inplane damping data were obtained for rotor operation between 350 and 425 rpm for thrust coefficients (CT/sigma) between 0.0 and 0.12. At constant rotor thrust, a minimum in rotor inplane damping was measured at 400 rpm. Good agreement is shown between experimental performance data and predicted performance. The influence of different aerodynamic inflow models on predicting damping levels is also shown. The best correlation with experimental stability data was obtained when a dynamic inflow model was used instead of static or quasistatic inflow models. Comparison with other full scale, hingeless rotor data in hover is presented. The hingeless rotor data and data from a full scale, bearingless main rotor test performed on the same general purpose test apparatus were compared. Although the bearingless rotor was more highly damped at design tip speed and 1-g thrust operation, greater sensitivity to operating conditions is shown. At low thrust levels the bearingless main rotor is less damped than the hingeless rotor. E.A.K.

**A86-26145#**

### STUDIES OF ROTORCRAFT AGILITY AND MANEUVERABILITY

H. C. CURTISS, JR. (Princeton University, NJ) and G. PRICE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 22 p. refs

Current rotorcraft maneuverability models are derived from high speed fixed-wing simulations and do not accurately represent the unique maneuvers or limits associated with rotorcraft. Two simplified rotorcraft models are derived which are valid at low speeds and in uncoordinated flight and can be used to examine some of the fundamental aspects of maneuverability and agility. The approach taken is to separate the total induced power and propulsive power above that for steady level flight from the usual expression for total power required. The sum of the induced and propulsive power is then expressed in terms of the horizontal and vertical accelerations in the maneuvering state. Maneuver limits can then be calculated in terms of vehicle design parameters. At low speeds, the attainable levels of acceleration, deceleration, climb, and load factor depend on available control power, control rates, and pilot limits as well as installed power. Because of the direct connection between body attitude and acceleration, it is suggested that an auxiliary thruster would increase vehicle agility, especially at low speeds. Author

**A86-26146#**

### A COMPUTER BASED STUDY OF HELICOPTER AGILITY, INCLUDING THE INFLUENCE OF AN ACTIVE TAILPLANE

S. HOUSTON and A. E. CALDWELL (Glasgow, University, Scotland) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p. refs

A computer-based study of combat-helicopter agility in longitudinal maneuvers is presented, comparing the agility ratings of four helicopters with the same stiff-flapwise rotor and speed (185 km/hr), but different horizontal tailplane configurations. Agility is quantified by the geometry of the maneuver and the time taken to perform it, subject to the limiting hub moment. Vehicle equations solved using an inverse method determined that the helicopter with a controllable tailplane, as the most agile, could fly bobups to 50 m up to 10 percent more quickly than the fixed-tail/least agile one, and hence required less airspace to maneuver. Because the control law is a function of the three tail rotor controls and the pitch rate, it is suggested that such a tailplane would need to be actively controlled, and an integrated element of the helicopter flight control system. R.R.

**A86-26157#**

### ELECTPICAL CONNECTIONS AND ANTENNA PERFORMANCE OF A LARGE COMPOSITE FUSELAGE MODULE IN THE HIGH FREQUENCY RANGE

M. J. HESELTINE and W. G. BOUGHTON (Westland Helicopters, Ltd., Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 14 p.

The utilization of carbon fiber composites in the design of airframes presents certain problems from an electrical point of view. The present paper is concerned with investigations which were conducted with respect to these problems, taking into account comparative measurements undertaken with an HF antenna fitted to an equivalent metal structure and subsequently onto an Advanced Technology Fuselage (ATF). It was found that an HF antenna mounted on a carbon fiber ground plane exhibits greater losses than the same antenna mounted on a similar sized metal ground plane at frequencies in the range from 2 MHz and 30 MHz, taking into account the use of low current measurement techniques. G.R.

**A86-26161#**

### A REVIEW OF RAE EXPERIMENTAL TECHNIQUES FOR ROTOR DYNAMICS AND AERODYNAMICS

F. B. MOULANG (Royal Aircraft Establishment, Bedford, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p. refs

The development of RAE in-flight experimental techniques for flight research into the detailed aerodynamics, blade motion, structural loading, and temperature distribution of helicopter rotors is reviewed, with emphasis on the most recent employment of data acquisition systems. Main rotor blade modification procedures for mounting strain gages and pressure sensors (stressing the 'glove' technique), in addition to their requirements for flight safety and airworthiness, are discussed. The signal conditioning circuitry uses multichannel slip ring assemblies to supply power to the rotor head and address the sensor amplifiers. The introduction of digital magnetic tape as the prime recording medium alloys data acquisition at a high rate as required by the rotor dynamics. The development of DATAMAP, allowing the generation of a wide variety of display formats, will make possible the direct comparison of measured and predicted data. A special chamber was constructed for the calibration of the large number of sensors involved. R.R.

**A86-26162**

### TESTS ON A NEW DYNAMICALLY SCALED MODEL ROTOR IN THE RAE 24 FT WIND TUNNEL

J. T. CANSDALE, R. J. MARSHALL, and P. A. THOMPSON (Royal Aircraft Establishment, Farnborough, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 19 p. refs

A new dynamically scaled rotor has been developed for the RAE model rotor rig in the 24ft Wind Tunnel. Two trials have been conducted during 1983, with the aim of acquiring experimental data for validation of loads prediction methods and guiding their further development. Major features of the 3.6 m diameter rotor are the composite blades with RAE 9642 section and built-in twist, and the dual load path hub. The latter is readily adaptable to allow variation of basic design parameters. The design and development of the rotor system is described, together with other new experimental equipment such as the data acquisition system. The trials are summarised, and a selection of results are presented covering loads measured in both the primary and secondary load path components. Comparable theoretical predictions are presented and discussed. Plans for further developments of the test facility and the rotor itself are outlined. Author

**A86-26163#**

### DESIGN AND TESTING OF A LARGE SCALE HELICOPTER FUSELAGE MODEL IN THE RAE 5 METRE PRESSURIZED WIND TUNNEL

F. T. WILSON (Westland Helicopters, Ltd., Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 16 p.

The design and preliminary results of a helicopter fuselage wind tunnel experiment to study the influence of Reynolds number on a number of important airframe aerodynamics parameters are discussed. High Reynolds number testing has been identified as a requirement to optimize aerodynamic design and minimize drag for future helicopter designs. A versatile helicopter-airframe-test rig was built to support the various large-scale fuselage and cowl shapes to be tested, and to provide a means to measure rotor head forces and moments. Preliminary small-scale low Reynolds number tests determined the optimum configuration for the study, which used a 5/16 scale in a 5 m wind tunnel over a range of Reynolds numbers from 2.46 times 10 to the 6th per meter, to 17.44 times 10 to the 6th per meter. An RTM 322 engine and a gearbox size no greater than that of the W30 were assumed, and a rigid five bladed rotor head was used for this first test. No unexpected Reynolds number effects on fuselage/cowl longitudinal characteristics were noted, but large changes in rotor head drag with Reynolds number, and some 'critical' drag changes were observed. R.R.

**A86-26164#**

### TESTS ON WHOLE A129 ENGINE BAY SIMULATING THE INERTIA AND AERODYNAMIC LOADS

G. GODIO (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 11 p.

These experimental tests are conducted to verify the safety of engine bay of the A129 helicopter in the event of fire. The importance of loads application during the tests are fundamental, because they allow the integrity of engine bay and underlying frame to be checked under actual flight conditions during fire hazard. The inertia loads simulation is carried out with hydraulic cylinders, while the aerodynamic loads are simulated with fans. The engine inlet and outlet are simulated with air flow. The tests are conducted with diffuse flame to verify the engine bay capability to contain the flame and with concentrate flame to verify the strength of installation parts under load. These results make it possible to warranty the safety of engine installation under all fire conditions and to optimize traditional and new materials. Author

**A86-26165#**

### SIMULATION CONCEPTS AND TESTING OF THE TAIL ROTOR FLY-BY-WIRE SYSTEM OF THE A129 HELICOPTER

M. ZAVA and G. MARIANI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p.

Attention is given to simulation concepts developed for the A129 antitank helicopter's fly-by-wire tail rotor system, and to the importance of its interconnection with the redundancy management capabilities of the A129's Integrated Multiplex System. The simulation focuses on system responses to both hydraulic and electronic failures; the software and hardware employed in the simulation testing process are noted, with emphasis on features dedicated to failure simulation. The results obtained are subjected to critical evaluation. O.C.

**A86-26167#**
**HC-MK1 (CHINOOK) HEATED ROTOR BLADE ICING TEST. I - TEST VEHICLE, TEST SITE, APPROACH AND SUMMARY OF TESTING**
K. LUNN (Boeing Vertol Co., Philadelphia, PA) and R. CURTIS (Aeroplane and Armament Experimental Establishment, Boscombe Down, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p. refs

Extensive modifications made on a standard HC-MkI Chinook helicopter to provide a test vehicle that could take full advantage of available natural icing conditions are described. Reasons for selecting CFB Shearwater in the Canadian Maritimes as the test site are discussed and data to support this choice are presented. The performance of the tests is briefly described. C.D.

**A86-26168#**
**HC-MK1 (CHINOOK) HEATED ROTOR BLADE ICING TEST. II - ANALYSIS OF ATOMOSPHERIC CONDITIONS, AIRCRAFT AND SYSTEMS CHARACTERISTICS**
P. DUNFORD (Boeing Vertol Co., Philadelphia, PA) and R. FINCH (Aeroplane and Armament Experimental Establishment, Boscombe Down, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 25 p. refs

Procedures to develop and optimize the HC-Mk1 (Chinook) heated rotor blade device system are presented and discussed. Analytical aspects of the test program are covered with special emphasis on the analysis techniques employed to process performance, flight loads, and blade temperature data in flight. Trial results from the latest winter trials are presented, and plans for next winter's testing are outlined. C.D.

**A86-26169#**
**HELICOPTER VIBRATION FLIGHT TESTING - THE ROTORTUNER APPROACH**
N. TRIGG (Helitune MCT, Ltd., Fleet, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 21 p.

A cost-effective and timely means of helicopter vibration management and research using the Rotortuner is described. The problem of helicopter vibration and the basic requirements of a vibration management system are summarized, and the advantages and disadvantages of existing equipment for vibration management are described. The main features of the Rotortuner system are presented, and their operation is briefly described. C.D.

**A86-26299**
**TOMORROW . . . CONCORDE'S SUCCESSOR?**
G. CORMERY (Aerospatiale, Division Avions, Paris, France) and G. PATRI Revue Aerospatiale (ISSN 0065-3780), Feb. 1986, p. 10-15. In English and French.

The current state-of-the-art in supersonic transport is discussed along with studies for the development of the Future (second-generation) Supersonic Transport (FSST). Technological advances flight-proven in Concorde's 10 years of commercial experience include full-authority fly-by-wire controls on all three axes and on the engine, digital computers, and an automatic flight management system. Studies for the development of an FSST center on wind-tunnel model testing using the following parameters: Mach 2-2.2, 50 percent aerodynamic, propulsion and weight improvement over the Concorde, an 8000 km/200 passenger profile with 1000 km subsonic flight, the use of existing airport installations, and ICAO A.16.1971 subsonic aircraft noise limitations. The adoption of a variable-cycle engine providing a bypass flow at subsonic regimes and a single flow for supersonic flight will provide the best compromise between general performance and noise limitations. Other projected technologies include the extensive use of the control-configured vehicle concept, permitting flight with zero static margins. R.R.

**N86-18316#** Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
**EFFECTIVENESS OF FATIGUE LIFE ENHANCING FASTENERS IN THE DESIGN AND REWORK OF AIRCRAFT STRUCTURES Final Report, Feb. 1982 - Feb. 1985**
P. A. KOZEL 28 Feb. 1985 31 p
(Contract F41-420)
(AD-A159676; NADC-85112-60) Avail: NTIS HC A03/MF A01 CSCL 13E

Fatigue life data were obtained for four different types of fatigue life enhancing (FLE) fasteners installed in new uncracked holes and in reworked, pre-cracked holes. The first condition represented a new design where the FLE fasteners are installed during production. The second condition represented a structural rework in which fastener holes are reamed to a larger size to remove fatigue or fretting damage but might still contain a small undetected crack. Results showed that the FLE fasteners produced approximately the same overall fatigue life in the new design and the rework condition and provided a significant increase in life compared to conventional non-FLE fasteners. Tests were performed with 7075-T6 aluminum alloy under spectrum loading typical of a Navy fighter/attack type of aircraft. For the rework condition, the pre-crack size was limited to .03 inch (.76mm). Flush head fasteners were used in all tests. GRA

**N86-18317#** Army Aviation Research and Development Command, Moffett Field, Calif. Aeroflightdynamics Directorate.
**EFFECTS OF BLADE-TO-BLADE DISSIMILARITIES ON ROTOR-BODY LEAD-LAG DYNAMICS**
M. J. MCNULTY 1985 29 p
(AD-A160497) Avail: NTIS HC A03/MF A01 CSCL 01C

Small blade-to-blade property differences are investigated to determine their effects on the behavior of a simple rotor-body system. An analytical approach is used which emphasizes the significance of these effects from the experimental point of view. It is found that the primary effect of blade-to-blade dissimilarities is the appearance of additional peaks in the frequency spectrum which are separated from the conventional response modes by multiples of the rotor speed. These additional responses are potential experimental problems because when they occur near a mode of interest they act as contaminant frequencies which can make damping measurements difficult. The effects of increased rotor-body coupling and a rotor shaft degree of freedom act to improve the situation by altering the frequency separation of the modes. Author (GRA)

**N86-18318#** Mechanical Technology, Inc., Latham, N. Y.
**INTERACTIVE EFFECTS OF HIGH- AND LOW-FREQUENCY LOADING ON FATIGUE Final Technical Report, 1 Sep. 1982 - 31 Dec. 1984**
A. PETROVICH May 1985 158 p
(Contract F33615-82-C-5056)
(AD-A160601; MTI-85TR48; AFWAL-TR-85-4045) Avail: NTIS HC A08/MF A01 CSCL 20K

This report describes the results of a program to measure and model the controlling mechanisms of fatigue and creep-crack growth behavior of a typical aircraft engine disk material under high frequency/low frequency loading cycles. The goal of the program is to provide a basis for damage-tolerant design of aircraft engine components under combined high and low frequency loading. Author (GRA)

**N86-18319#** Army Research and Technology Labs., Moffett Field, Calif.

**AN INVESTIGATION OF THE USE OF BANDWIDTH CRITERIA FOR ROTORCRAFT HANDLING-QUALITIES SPECIFICATIONS**

C. L. BLANKEN, C. C. BIVENS, and M. S. WHALLEY 1985 15 p Presented at the International Conference, Rotorcraft Basic Research, American Helicopter Society, Research Triangle Park, N.C., 19-21 Feb. 1985

(AD-A160664; NAS 1.26:176709; NASA-CR-176709) Avail: NTIS HC A02/MF A01 CSCL 01A

The objective of this study was to investigate bandwidth concepts for deriving rotorcraft handling-qualities criteria from data obtained in two simulator experiments conducted at the Aeromechanics Laboratory. The first experiment was an investigation of the effects of helicopter vertical-thrust-response characteristics on handling qualities; the second experiment investigated the effects of helicopter yaw-control-response characteristics. In both experiments, emphasis was on low-speed Nap-of-the-Earth (NOE) tasks. GRA

**N86-18320#** Aeronautical Research Labs., Melbourne (Australia).

**THE TEST LOADS SEQUENCES APPLIED TO THE CT4 FULL SCALE FATIGUE TEST**

L. R. GRATZER Jun. 1985 25 p

(AD-A160736; ARL-STRU-TM-415) Avail: NTIS HC A02/MF A01 CSCL 01A

This document presents an outline of the derivation of the test load sequences applied to the CTA full scale fatigue test. GRA

**N86-18321#** Aeronautical Research Labs., Melbourne (Australia).

**RESONANCE FATIGUE TEST OF THE EMPENNAGE OF A CT4 AIRCRAFT**

I. ANDERSON and L. MOLENT Jun. 1985 36 p

(AD-A160749; ARL/STRUC-TM-412) Avail: NTIS HC A03/MF A01 CSCL 01C

A resonance fatigue test was carried out on the rear fuselage and empennage of a CT4 aircraft. The structure was supported in a reaction frame, and was excited at the resonant frequency of the fuselage torsional mode (9 Hz) by electromagnetic shakers connected to the tailplane. The loading spectrum applied was based on strain sequence data obtained from flight trials. Regular inspections of the structure were carried out, and several areas on the rear fuselage and empennage were identified as being prone to fatigue damage. GRA

**N86-18322#** Army Aviation Engineering Flight Activity, Edwards AFB, Calif.

**PRELIMINARY AIRWORTHINESS EVALUATION OF THE AH-1S (MODERNIZED COBRA) WITH THE HELLFIRE, TOW, AND STINGER MISSILES INSTALLED Final Report, 17 May - 27 Jul. 1984**

R. MACMULLIN, G. T. DOWNS, E. TAVARES, J. S. LAWRENCE, and L. L. TODD Oct. 1984 188 p

(AD-A160862; USAAEFA-84-11) Avail: NTIS HC A09/MF A01 CSCL 01B

The aircraft was operated at gross weights up to 10,400 lb, up to 11,340 feet density altitude and at a lateral center of gravity (cg) range from one inch right to approximately three inches left. The asymmetric loadings were caused by the various combinations of armament configurations. The change in equivalent flat plate area compared to the clean aircraft for each configuration varied as a function of airspeed. At 130 knots true airspeed (KTAS), the increased flat plate area was 4.2 square feet for the Launcher configuration, 4.8 square feet for the TOW configuration, 6.6 square feet for the Hellfire and Hellfire/TOW configurations, and 7.8 square feet for the Stinger/Hellfire/TOW configuration. The increase in flat plate area for the Stinger/Hellfire/TOW configuration reduced maximum level flight speed for normal rated power by approximatley 8 KTAS. With the exception of the two armament related shortcomings listed below, the handling qualities and the reactions to system failures of the AH-1S (MC) were not significantly changed by the asymmetric loading of the various armament configurations. Four shortcomings were noted and follow in decreasing order of importance: (1) the high left rolling response to a sudden engine failure at power settings above 75% torque; (2) the undesirable maneuvering stability characteristics above 1.4 g's; (3) insufficient left pedal margin available in right sideward flight above 10 knots in the Hellfire and Hellfire/TOW configurations; and (4) insufficient left pedal margin available for ball-centered forward flight below 30 KCAS in the armament configurations with left lateral cf offset. A CAUTION is recommended for inclusion in the operator's manual. GRA

**N86-18323#** Joint Publications Research Service, Arlington, Va.

**USSR REPORT: TRANSPORTATION**

19 Dec. 1985 110 p Transl. into ENGLISH from various Russian articles

(JPRS-UTR-85-015) Avail: NTIS HC A06

Developments in transportation are reported from the Soviet Union. Among the topics discussed are: (1) civil aviation; (2) motor vehicles and highways; (3) rail systems; (4) maritime and river fleets; (5) ports and transshipment centers; (6) intersector network development; and (7) experimental systems.

**N86-18324#** Joint Publications Research Service, Arlington, Va.

**SUKHOY DESIGN BUREAU BUILDS SPORT PLANE MADE OF PLASTIC**

V. BELIKOV *In its* USSR Report: Transportation (JPRS-UTR-85-015) p 4-5 19 Dec. 1985 Transl. into ENGLISH from Izvestiya (Moscow, USSR), 16 Aug. 1985 p 3

Avail: NTIS HC A06

The design and construction of the Soviet Su-26 aircraft is discussed. The Su-26 is a sports aircraft which makes extensive use of plastic materials in its construction. G.L.C.

**N86-18325#** Joint Publications Research Service, Arlington, Va.

**FEATURES OF PLANNED IL-96-300, IL-114 AIRCRAFT**

G. V. NOVOZHILOV *In its* USSR Report: Transportation (JPRS-UTR-85-015) p 6-11 19 Dec. 1985 Transl. into ENGLISH from Pravda (Moscow, USSR), 27 Oct. 1985 p 6

Avail: NTIS HC A06

In accordance with the tradition, the general designer directly guides any new aircraft up to the conclusion of state testing, but this does not mean that he stops watching the aircraft closely during operation as well. Such an aircraft is now in the Experimental Design Bureau imeni S. Ilyushin--the Il-96-300 long-range mainline passenger aircraft. It is designed to carry 300 passengers, baggage, mail and freight on long-distance routes--up to 9,000 kilometers--with heavier passenger flows. Provision is being made for use of the aircraft on international routes, including those up to 11,000 kilometers in length. G.L.C.

**N86-19312*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**GROUND VIBRATION TEST RESULTS FOR DRONES FOR AERODYNAMIC AND STRUCTURAL TESTING (DAST)/AEROELASTIC RESEARCH WING (ARW-1R) AIRCRAFT**

T. H. COX and G. B. GILYARD Jan. 1986 36 p refs

(NASA-TM-85906; H-1261; NAS 1.15:85906) Avail: NTIS HC A03/MF A01 CSCL 01C

The drones for aerodynamic and structural testing (DAST) project was designed to control flutter actively at high subsonic speeds. Accurate knowledge of the structural model was critical for the successful design of the control system. A ground vibration test was conducted on the DAST vehicle to determine the structural model characteristics. This report presents and discusses the vibration and test equipment, the test setup and procedures, and the antisymmetric and symmetric mode shape results. The modal characteristics were subsequently used to update the structural model employed in the control law design process. Author

**N86-19313*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DYNAMICS AND CONTROLS FLIGHT TESTING OF THE X-29A AIRPLANE**

J. GERA Jan. 1986 13 p refs Presented at the 24th AIAA Aerospace Sciences Meeting, Reno, Nev., 6-9 Jan. 1986
(NASA-TM-86803; H-1333; NAS 1.15:86803; AIAA-86-0167)
Avail: NTIS HC A02/MF A01 CSCL 01C

A brief description of the flight control system of the X-29A forward-swept-wing flight demonstrator is followed by a discussion of the flight test techniques and procedures in the area of flight dynamics and control. These techniques, which evolved during the initial few months of flight testing, are based on integrating flight testing with simulation and analysis on a flight-by-flight basis. A limited amount of flight test results in dynamic stability and handling qualities is also presented. Author

**N86-19314*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HOVER AND FORWARD FLIGHT ACOUSTICS AND PERFORMANCE OF A SMALL-SCALE HELICOPTER ROTOR SYSTEM**

C. KITAPLIOGLU and P. SHINODA 13 Sep. 1985 29 p Prepared in cooperation with Army Aviation Research and Development Command, Moffett Field, Calif., and City Univ., London, Engl.
(NASA-TM-88584; NAS 1.15:88584; AD-A160661) Avail: NTIS HC A03/MF A01 CSCL 20A

A 2.1-m diam., 1/6-scale model helicopter main rotor was tested in hover in the test section of the NASA Ames 40- by 80- Foot Wind Tunnel. Subsequently, it was tested in forward flight in the Ames 7- by 10-Foot Wind Tunnel. The primary objective of the tests was to obtain performance and noise data on a small-scale rotor at various thrust coefficients, tip Mach numbers, and, in the later case, various advance ratios, for comparisons with similar existing data on full-scale helicopter rotors. This comparison yielded a preliminary evaluation of the scaling of helicopter rotor performance and acoustic radiation in hover and in forward flight. Correlation between model-scale and full-scale performance and acoustics was quite good in hover. In forward flight, however, there were significant differences in both performance and acoustic characteristics. A secondary objective was to contribute to a data base that will permit the estimation of facility effects on acoustic testing. GRA

**N86-19315#** JAI Associates, Mountain View, Calif.

**AERODYNAMICS OF TWO-DIMENSIONAL BLADE-VORTEX INTERACTION**

G. R. SRINIVASAN, W. J. MCCROSKEY, and J. D. BAEDER 1985 20 p Previously announced in IAA as A85-40685
(Contract DAAG29-85-C-0002)
(AD-A160662) Avail: NTIS HC A02/MF A01 CSCL 01C

A computational procedure and some numerical results of unsteady interaction of a helicopter rotor blade with a Lamb-like vortex of finite viscous core in subsonic and transonic flows is presented. The interaction considered here is one of the limiting cases of a more complex interaction typically encountered on helicopter rotor blade. In this limit, the interacting flow field is considered to be unsteady but two-dimensional. Accordingly, unsteady, two-dimensional, thin-layer Navier-Stokes equations are solved using a prescribed-vortex method (also called perturbation method) for the cases of stationary and moving rotor blades encountering a moving vortex passing the blades. The numerical results are compared with the recent experimental data of Caradonna et al. for the latter case. The comparison shows that for the transonic cases, the flow field is dominated by the presence of the shock waves, with strong indications of unsteady time lags in the shock-wave motions and shock-wave strengths, and of important three-dimensional effects. For subcritical-flow cases, however, the unsteady lag effects on the basic rotor blade are absent, and three-dimensional effects appear to be negligible, unlike the supercritical case. The subcritical calculations are in good agreement with the experimental data. GRA

**N86-19316#** Army Aviation Systems Command, St. Louis, Mo.

**CORRELATION OF RESULTS OF AN OH-58A HELICOPTER COMPOSITE TAIL BOOM TEST WITH A FINITE ELEMENT MODEL**

N. CALAPODAS and K. HOFF Sep. 1985 32 p
(Contract DA PROJ. 1L1-62209-AH-76)
(AD-A161062; USAAVSCOM-TR-85-D-15) Avail: NTIS HC A03/MF A01 CSCL 01C

The results of testing an OH-58A composite tail boom and comparing its static and dynamic characteristics with those obtained from finite element analyses are presented in this report. Static load versus deflection data were used to verify the stiffness representation of the finite element model. Ground vibration test data were used to evaluate frequency and modal responses obtained from analysis. Discussions of each test configuration, including data analysis methodology and correlation results, are presented. Differences between measured static deflections and finite element analysis calculated deflections range from 6 to 12 percent. Natural frequency differences between test and analysis were less than 5 percent for the first and second elastic modes. Problems encountered during the testing and the impact on correlation are also discussed. GRA

**N86-19318#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**FLIGHT TEST EVALUATION OF THE NETHERLANDS FLIGHT INSPECTION AIRCRAFT**

D. GEELS 14 May 1984 43 p refs Presented at 3rd International Flight Inspection Meeting, Ottawa, Ontario 28 May-1 Jun. 1984
(NLR-MP-84052-U; B8571448) Avail: NTIS HC A03/MF A01

Flight test evaluation of a flight inspection aircraft (Cessna Citation 500) equipped with position sensors, calibrated navaids receivers and a fully automatic data acquisition and data processing system for the real-time calibration and inspection of radionavigation and instrument landing systems was carried out. For the evaluation and acceptance of the en-route part of the system, a small, light-weight flexible data acquisition system was installed. Using a specially developed software package, high accuracy position reference data was computed off-line to demonstrate the CFIS navaids en route calibration performance and to determine the overall navigation accuracy of the flight inspection and navigation system during the calibration flights. The distance measuring equipment position reference method, the function and the operational principle of the flight inspection system, additional test equipment, and the data processing are described. Author (ESA)

**N86-19319#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**DETERMINATION OF LIMITATIONS FOR HELICOPTER SHIP-BORNE OPERATIONS**

C. F. G. M. HOFMAN and R. FANG 15 Aug. 1984 14 p Presented at 10th European Rotorcraft Forum, The Hague, Netherlands, 28-31 Aug. 1984 and RINA International Symposium on Air Threat at Sea, London, England, 11-14 Jun. 1985
(NLR-MP-84072-U; B8572249) Avail: NTIS HC A02/MF A01

The organization of helicopter-ship qualification trials based on experience with trials with various helicopter types on different classes of ships is discussed. Procedures applied are described and illustrated. Author (ESA)

**N86-19836#** Joint Publications Research Service, Arlington, Va.

**IMPROVING COMMERCIAL AIRCRAFT TRAINING SIMULATORS**

V. GORYACHEV *In its* USSR Report: Life Sciences. Biomedical and Behavioral Sciences (JPRS-UBB-86-001) p 48-49 2 Jan. 1986 Transl. into ENGLISH from Vozdushnyy Transport (Moscow, USSR), 10 Sep. 1985 p 3
Avail: NTIS HC A06

Studies of the use of technical means of instruction was begun in 1976. Results of this research indicated that training with simulators could take the place of flight training of crews in preparation for spring and summer flight operations. Instructions from the Ministry of Civil Aviation to this effect were issued in 1977. This change has proved effective. Effective use of comprehensive training simulators has become an important way of saving fuel. Flight training in flight schools still takes up a large portion of their time, the benefit yielded by helicopter training simulators still is not large enough, and possibilities exist for reducing unproductive flight time in a whole series of training programs for flight crews. Author

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-22720**
**ADVANCED MEDIUM SCALE REAL-TIME SYSTEM**
A. L. KELLEY (Fairchild Weston Systems, Inc., Data Systems Div., Sarasota, FL) IN: European Telemetry Conference, 7th, Boeblingen, West Germany, May 21-24, 1984, Reports. Part 2 . Wessling, West Germany, Arbeitskreis Telemetrie, 1984, p. 7.1-7.1.16.

In 1960, the U.S. Army Aviation Engineering Flight Activity (USAAEFA) was formed to perform flight test evaluations of Army aircraft. In 1977, the USAAEFA initiated an investigation regarding the feasiblity of replacing the previous system because of age and lack of growth potential. With respect to the selection of a replacement system, an architecture was to be chosen which would not utilize hardware or software capabilities considered to be 'pushing the state-of-the-art'. Attention is given to the definition of an optimum system, questions of engineering interaction, the man-machine interface, a system description, the telemetry acquisition subsystem, the preprocessing system, the computer system, the operating system, the setup and application software, and a data flow overview. G.R.

**A86-22728**
**THE DATA TRANSMISSION AND PROCESSING EQUIPMENT OF A HIGH-PRECISION TRAJECTORY MEASUREMENT SYSTEM [DIE DATENUEBERTRAGUNGS- UND -VERARBEITUNGSEINRICHTUNGEN EINES HOCHPRAEZISEN FLUGBAHNVERMESSUNGSSYSTEMS]**
P. SCHULZ (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) IN: European Telemetry Conference, 7th, Boeblingen, West Germany, May 21-24, 1984, Reports. Part 2 . Wessling, West Germany, Arbeitskreis Telemetrie, 1984, p. 8.11-8.11.11. In German.

A measurement system has been designed for the study of approach and landing systems. The aircraft employed for the experiments contains an onboard device of the system to be tested and, in addition, equipment of the measurement system. In ground tests, the aircraft is replaced by a ground test vehicle. On the ground at the airport, the ground stations of the landing system to be studied together with stations of the measurement system are located at suitably selected positions. A suitable system for data processing operations is needed for the conduction of the required flight and ground tests. This data system has to perform functions related to data acquisition and transmission, data processing and storage, and data display. Details regarding the conduction of the required operations are discussed. G.R.

**A86-23255**
**ENGINE/AIRFRAME HEALTH AND USAGE MONITORING AN ALTERNATE APPROACH VIA ADVANCED VIBRATION MONITORING SYSTEMS**
M. D. FLOYD (Vibro-Meter, S.A., Fribourg, Switzerland) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 4-1 to 4-11.

The paper describes the latest developments in advanced vibration monitoring systems and their logical extension to provide an integrated engine/airframe health and usage monitoring package. Such systems require close cooperation between supplier and engine/airframe manufacturer during development, flight test and service operation in order to establish the data base used to make the system intelligent. Author

**A86-23272**
**INFLIGHT RESOLUTION EVALUATION FOR THERMAL IMAGING SYSTEMS**
S. E. SHIMER (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 21-1 to 21-5.

This paper presents a method to determine the resolution of an airborne Thermal Imaging System (TIS) under the conditions and in the environment of typical operation. By determining the resolution of the entire system (e.g., sensor, aircraft, display, pilot) a more realistic measure of the system's true resolution can be determined. The effects of Atmospheric Transmission and Target Radiation are also included in the evaluation. Author

**A86-23275**
**AIR FORCE FLIGHT TEST INSTRUMENTATION SYSTEM - AN INTRODUCTION FOR FLIGHT TEST ENGINEERS AND MANAGERS**
J. M. POSNER and R. A. KITCHEN (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 24-1 to 24-11.

The design and development of the Air Force Flight Test Instrumentation System (AFFTIS) are described. The proposed design of the AFFTIS is a digital modular system with remote sensing multiplex capability and is based on the use of data acquisition units (DAUs). The hardware for the AFFTIS, which includes an AFFTIS system controller, a data bus, a system power supply, DAUs, cockpit data displays, and the Analog-Discrete Data Acquisition Unit, are examined. The Laboratory Support System, Ground Support Unit, and Remote Site Unit are applied to hardware unit testing, software programming for the test configuration formats, and on-aircraft checks of the installed instrumentation hardware. The organizational, intermediate, and depot level maintenances, and the role of the system manager are analyzed. The economical advantages the AFFTIS provides are studied. I.F.

**A86-23293**
**AIRBORNE RADAR. I - AIR-TO-SURFACE**
J. CLARKE (Royal Signals and Radar Establishment, Malvern, England) and C. M. STEWART (Ferranti, PLC, Edinburgh, Scotland) Microwave Journal (ISSN 0026-2897), vol. 29, Jan. 1986, p. 32, 34, 36 (5 ff.).

Airborne radar has retained its attraction as a sensor, despite the development of alternative technologies. The reasons for this situation are related to the flexibility of radar in adapting to a wide range of operations roles, a relative immunity to weather conditions, and an ability to detect relatively small targets at considerable distances. Recent developments are related to the innovation of powerful, high speed computers suitable for airborne use, and the adoption of coherent radar systems relying on the use of an RF power amplifying tube rather than the self-oscillating magnetron. This paper provides a review of the various classes of airborne radars in the light of the introduction of new capabilities. Attention is given to air-to-surface roles, sea surface reconnaissance, land reconnaissance, close air support and strike, and terrain clearance. G.R.

**A86-23313**

**A VME BUS MICROCOMPUTER SYSTEM FOR EXPERIMENT CONTROL AND ANALYSIS ON BOARD AN AIRCRAFT**

A. J. DEMPSTER (Wellington, Victoria University, New Zealand) New Zealand Journal of Technology (ISSN 0112-3890), vol. 1, April 1985, p. 53-60. Research supported by the New Zealand Meteorological Service. refs

The severe mechanical environment on board an aircraft requires that special consideration be given to the selection of equipment for experiment control and analysis. In the system described in this paper, the VME bus and Motorola 68000 were chosen. These combine a modern state-of-the-art 16-bit microprocessor with a secure mounting system and a wide range of experiment interfaces configured from standard Eurobus boards. A real-time operating system and applications software were written in the high-level language 'C'. This provides sufficient structure facilities with enough access to machine-level components. With certain safeguards it was possible to place all object code in ROM. All software was developed on a host computer using cross-compiler and cross-assembler. The approach taken was dictated mainly by cost but has met the initial requirements of real-time experiment control and data analysis. Author

**A86-23728*** Michigan Univ., Ann Arbor.

**THE UTILITY OF HEAD-UP DISPLAYS - EYE-FOCUS VS DECISION TIMES**

D. J. WEINTRAUB (Michigan, University, Ann Arbor), R. F. HAINES, and R. J. RANDLE (NASA, Ames Research Center, Moffett Field, CA) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1984, p. 529-533.

Instrument-panel information is presented by a Head-Up Display (HUD) to pilots in such a way that the symbols appear far away (at optical infinity) superimposed upon the landscape. The use of a HUD makes it, therefore, unnecessary for the pilot to take his eyes off the changing scene in order to look down and refocus on the instrument panel. It is pointed out that the HUD has proved superior to the conventional instrument-panel display. An experiment was conducted with the objective to help to determine which of the differences between HUD and conventional instrument-panel display are mainly responsible for the superiority of the HUD. Important features of this experiment are that the format of each virtual-image display, its luminance, and its angle subtended at the eye, remained the same as the optical distance and location were varied. It was found that the HUD symbology at optical infinity does reduce decision times compared to the same format at the location of a conventional instrument panel. G.R.

**A86-23729**

**A PRELIMINARY FLIGHT EVALUATION OF THE PERIPHERAL VISION DISPLAY USING THE NT-33A AIRCRAFT**

V. GAWRON and L. KNOTTS (Calspan Advanced Technology Center, Buffalo, NY) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1984, p. 539-541. Research supported by the Department of National Defence of Canada.
(Contract F33615-79-C-3618)

The Malcolm Horizon, a Peripheral Vision Display (PVD), was installed in the NT-33A variable stability research aircraft to provide the evaluation pilot with a gyrostabilized horizon line of red laser light. An experiment was conducted to determine the effect of the PVD on pilot workload. Workload was inferred from performance on a secondary task, in this case the Sternberg task, generated by the Workload Assessment Device (WAD). The primary task required the pilot to maintain airspeed, altitude, and angle of bank during instrument flight conditions. Nine NT-33A flights were flown by two evaluation pilots. Presence of the PVD reduced the WAD reaction times of one of the pilots; the reaction times of the other pilot showed mixed results. Recommendations for future research are presented. Author

**A86-23762**

**AIRBORNE DIAGNOSTIC EQUIPMENT [TECHNICKE PROSTREDKY PALUBNI DIAGNOSTIKY]**

K. HORAK Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 237-242. In Czech.

The paper presents the general design and brief descriptions of the main components of an airborne recording system for maintaining records of routine flight and emergency data. The main technical and performance characteristics of the system are presented. The information presented here may be useful in considering some other applications for the recording system. V.L.

**A86-23763**

**THE MEASURING AND CONTROL UNITS OF AIRBORNE RECORDING SYSTEMS [MERICI A RIDICI JEDNOTKY PALUBNICH REGISTRACNICH ZARIZENI]**

J. BENDA and J. VIDIECAN Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 243-247. In Czech.

The general design and the main components of the equipment used for monitoring and processing of the parameters of the aircraft powerplant and other airborne systems are discussed. The principal factors affecting the design of the monitoring and control equipment are then examined, and current trends in the modernization of the airborne data acquisition systems are reviewed in relation to the available commercial hardware and special operating conditions. V.L.

**A86-23765**

**THE POSSIBILITY OF USING THE ON-BOARD COMPUTER FOR IN-FLIGHT DIAGNOSTICS [MOZNOSTI VYUZITI PALUBNIHO VYPOCETNIHO SYSTEMU PRO DIAGNOSTIKU V PRUBEHU LETU]**

M. KNEZOVIC Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1985, p. 253-257. In Czech. refs

The possibility of using the on-board digital computer for monitoring the condition of the aircraft and its components during the flight is examined. It is suggested that, in addition to routine flight data processing, such a system can monitor in real time the parameters characterizing the technical conditions of the aircraft and its systems, analyze this information, and issue a timely warning of the impending danger. V.L.

**A86-24583**

**SENSOR SYSTEM CONCEPT FOR FUTURE FIGHTER AND STRIKE AIRCRAFT [KONZEPT EINES SENSORSYSTEMS FUER ZUKUENFTIGE JAGD- UND KAMPFFLUGZEUGE]**

B. STIELER (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, Nov.-Dec. 1985, p. 339-348. In German. refs

Laser gyro multifunction inertial sensor assemblies (MISA) can be used for navigation, flight control, cockpit instrumentation, and computation of weapon delivery in future fighter and strike aircraft and will contribute to a reduction of an aircraft's life cycle costs. The internal MISA signal processing, which is adapted to increased laser gyro noise, is discussed. The potential for increased MISA navigational accuracy through the use of external sensors is considered, especially for automated terrain-following flight. The increased reliability required in sensor systems of control-configured vehicles will be attained by highly reliable sensors and a skewed montage, as in two MISAs. A special signal processing permits detection and identification of sensor or subsystem failure and the reconfiguration of the remaining system. The failure probability of various system configurations is calculated. C.D.

**A86-24827**

**DESIGN OF THE F-16 AIRCRAFT ELECTRICAL SYSTEM BUILT-IN-TEST MONITOR**

M. A. ROSSWURM (Cummins Engine Co., Columbus, OH) and L. L. TIPTON (Westinghouse Electric Corp., Electrical Systems Div., Hunt Valley, MD) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.367-1.373.

Built-In-Test (BIT) capability in aircraft electronic equipment has the potential to reduce maintenance effort and increase aircraft availability. This paper describes a BIT monitoring scheme used on a high performance fighter aircraft to detect and isolate faults in the electrical generation equipment. An overview of the BIT monitor is given, along with a detailed analysis of a typical subsystem BIT equation. The results and method of test for a hardware BIT demonstration are detailed. Some ideas and an example of improving the display of maintenance information by the use of graphic display devices are presented. Finally, some techniques are explored for simplifying the detection and isolation of electrical system faults through the use of remote diagnostic tools. Author

**A86-26006**

**THE HUD AS A PRIMARY FLIGHT INSTRUMENT**

P. B. LOVERING and . S. ANDES (Midwest Systems Research, Inc., Dayton, OH) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 33-36.
(SAE PAPER 841463)

The usefulness of head-up displays (HUDs) in the modern fighter aircraft is often impaired by the fact that the functions of HUD are not always intuitively obvious, and the HUD descriptions are sometimes confusing or incomplete. The aspects of current display symbology, mechanization schemes, needs, and some possible modifications are discussed. Use of identical terms to describe two different functions, variation in information content across the various HUDs, and use of multiple display formats in altitude and navigation displays are given as examples of inadequacies that diminish the HUD usefulness. The short-term steps suggested for improving the utility of existing HUDs include standardization of all symbols and fundamental display concepts. The long-term steps involve redesigning the HUD systems to make the displays easier to interpret and to use. I.S.

**A86-26007**

**PRESENTATION OF RADAR ALTITUDE INFORMATION ON THE HUD**

L. A. CARR (USAF, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 37-43. refs
(SAE PAPER 841464)

Radar altimeters are being included in several existing Air Force aircraft. Of these, the A-10, F-15, and the F-16 are also envisioned to perform the night, under the weather attack mission. This mission, coupled with limited available cockpit space and the anticipated high pilot workload has led to a design effort to include the radar altimeter on the HUD. The LANTIRN system offered a key opportunity to accomplish this HUD integration. The design has evolved from pilot opinions through simulation and now flight test. Plans are currently being made to conduct a simulation to make minor changes to the display based on test results to further optimize the display. This radar altimeter design and particularly the way the design has evolved should serve as examples for future efforts. Of particular note is that this display has been designed from the beginning for a specific purpose and is being optimized for its intended operational environment and the pilots who will use it. Author

**A86-26008**

**FLIGHT DECK DISPLAYS FOR MANAGING WIND SHEAR ENCOUNTERS**

R. G. JOPPA and R. K. NICHOLSON (Washington, University, Seattle) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 45-51.
(SAE PAPER 841465)

A concept of a flight energy instrument system is presented in which the rate of energy with respect to air is used to give the pilot a predictive indication of changes in descent rate due to the wind shear during the approach to landing. Rate of change of total energy is measured and compared to vertical speed, the difference being the change of vertical speed if the shear continues. Flight path angles are displayed on an electronic attitude indicator. In addition, a novel airspeed instrument is described which has two needles, one being the regular pointer to show the airspeed, and the other showing the sum of the airspeed plus the rate of change in the airspeed. The needle separation is a measure of the wind shear rate. Separation of turbulence from shear is accomplished by filtering. The two concepts may be implemented with commercially available hardware or by simple computations using an on-board air data system. I.S.

**A86-26010**

**ELECTRONIC DISPLAY OF POWERPLANT PARAMETERS**

D. K. GRAHAM (Boeing Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 61-67.
(SAE PAPER 841467)

Results of simulator testing of the seven-color CRT displays in the 757/767 Engine Indication and Crew Alert System are discussed. As a result of this evaluation, changes were made in the displays, such as removal of green bands from all gages, introduction of 'boxed' readouts, and format changes. In addition, results from simulator tests of the digital-only testing, done in support of the Standby Engine Indicator are presented. It was concluded that, while the digital-only displays appear to be not as good as the analog-plus-digital displays, their performance is acceptable, and they may have more operational utility than is commonly realized. I.S.

**A86-26012**

**PRESENTATION OF INFORMATION ON MULTIMODE DISPLAYS - ABNORMAL AND EMERGENCY AIRCRAFT OPERATIONS**

G. R. GERSHZOHN (Rockwell International Corp., Pittsburgh, PA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 75-83.
(SAE PAPER 841494)

The capability of a multimode display system to present data regarding malfunctioning aircraft systems is illustrated. The development of formats for abnormal operations is based on the correspondence between cognitive requirements of the pilot and displayed information. Three different stages of cognitive processing are identified and associated formats are developed. System architecture provides for the display of required information tailored to pilot requirements in identifying, understanding, and solving malfunctions via a simple multimode display interface. Author

**A86-26032**

**COCKPIT ADVANCES IN BOEING VERTOL COMPANY'S MODEL 360 HELICOPTER**

A. T. SHERBERT (Boeing Vertol Co., Philadelphia, PA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 237-241.
(SAE PAPER 841629)

The cockpit advances incorporated into the design of an advanced-composite Model 360 technology demonstration helicopter are described. Perhaps the most important feature of the helicopter will be its lighting system, which has been designed to accommodate both the sunlight readable and night vision goggle-compatible modes of operation. An advanced flight control system features an integrated system of six CRT displays and two data entry keyboards, and a multiplexing control display system to interface them and their supporting subsystems. In addition, the head clearance envelope was redesigned to minimize vehicle contour in the cockpit area; the cockpit area was designed to accommodate the 2nd through 98th percentile aviator with a wide range of anthropometric requirements, and the envelope of vision has been improved. I.S.

**A86-26129#**

**CRT DISPLAYS IN MODERN HELICOPTER DATA PRESENTATION**

M. R. DUELL (Westland Helicopters, Ltd., Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 23 p.

The use of CRT displays as Electronic Flight Instruments (EFIS) for helicopters, and their adoption for the cockpit designs of Westland's 30-300 and EH101, are discussed. The multicolored, multifunctional CRT display resulting in more efficient use of the instrument panel area, in addition to its capability of displaying Torque and Tacho, Hover, and search pattern information, contributes to a reduction in pilot workload and cost. However, the weight penalty and higher initial cost of the CRT displays can be minimized by the multiple use of displays via careful format definition. Certification of EFIS for civil helicopters requires comparable reliability to the electromechanical instruments it replaces, and a high level of system redundancy. EH101 display function requirements determined the choice of shadowmask CRT displays. The Westland 30-300 will incorporate EFIS into a system with interfaces between avionics and flight instrumentation already defined with possible adaptation. R.R.

**A86-26130#**

**VISUALLY COUPLED EO SYSTEM DEVELOPED FOR THE RAE SEA KING XV371**

I. MANSFELD (Royal Aircraft Establishment, Flight Systems Dept., Farnborough, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p.

This paper describes the development of a visually coupled system (VCS) and its assessment as a piloting and navigational aid for low level night operations. The overall aim is to define the requirements for each component of a VCS. The trials have been carried out using a Sea King helicopter as the trials vehicle, fitted with a rapid acting two degree of freedom platform capable of matching the head motion rates of the pilot. The sensor used on this platform is an Isocon low light TV camera, though an infrared sensor has been fitted for the next stage of trials. Two types of head position tracker have been used, one electromagnetic in principle and the other utilizing infrared light. Flight symbology has been superimposed onto the sensor image and presented to the pilot on a monocular helmet mounted display comprising a miniature CRT and optics. The results of the trials and their implications on the system components are described. The current trials equipment and plans for the next stage of investigations are discussed. Author

**A86-26132#**

**SAFETY ASPECTS IN STORES MANAGEMENT SYSTEMS**

F. CRISPOLTI and G. SCOTTI DI UCCIO (Selenia - Industrie Elettroniche Associate S.p.A., Pomezia, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p.

The system architecture of Stores Management Systems (SMS) in combat aircraft and rotorcraft is examined and related to safety and mission success. A general purpose SMS is outlined, and the main reliability parameters are defined. Mono channel systems, multichannel reconfigurable systems, and communication channels are presented and discussed. C.D.

**A86-26153#**

**THE HEALTH AND USAGE MONITORING SYSTEM OF THE WESTLAND 30 SERIES 300 HELICOPTER**

D. G. ASTRIDGE and J. D. ROE (Westland, PLC, Helicopter and Hovercraft Group, Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 19 p. refs

The design philosophy behind the health and usage monitoring developments on the Westland 30 series of helicopters is discussed including their relevance to the recently published review of helicopter airworthiness (HARP report). The necessity for a comprehensive on-board data processing system such as that described in this paper becomes patently obvious. The functions included in the system related to engines, the transmission, and rotor systems. Experience has been gained with the implementation of many of these functions separately on development and production aircraft. Details are given of the processor, its interfaces, data links, sensors, and data retrieval unit, together with an overview of the development program. Author

**N86-19321#** New Mexico State Univ., Las Cruces. Behavioral Engineering Lab.

**HORIZONTAL DISPLAY FOR VERTICAL FLIGHT: A DIRECTION OF MOTION EXPERIMENT**

E. J. TRUJILLO and S. N. ROSCOE May 1985 48 p
(Contract N00014-81-K-0439)
(AD-A161113; BEL-85-1/ONR-85-1) Avail: NTIS HC A03/MF A01 CSCL 01D

As a part of a research program to investigate advanced concepts for downward and forward-looking integrated displays, an experiment was conducted to determine optimum direction-of-motion relationships for a new way of presenting altitude and vertical rate information superposed on a downward-looking navigation and tactical situation display. Altitude was represented by the size of an octagon that could either dilate or constrict to indicate increasing altitude, and vertical rate was indicated by the outward or inward flow of four rate-field patterns emanating from the center of the display toward the 45, 135, 225, and 315-degree compass positions. The five factors in this experiment were altimeter and vertical rate-field direction of motion, subject ability level, aircraft vertical control order, and vertical flight course. Performance on four vertical flight profiles indicated that the out is up relationship yields superior vertical control, both in terms of control reversals and log RMS tracking precision, whereas the out is down mode results in more accurate control in the horizontal plane. GRA

## 07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-23273**

**A FLIGHT EVALUATION OF A DIGITAL ELECTRONIC ENGINE CONTROL**

A. T. WEBB and D. L. CORSENTINO (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 22-1 to 22-7.

A production F100-PW-200 engine incorporating a digital electronic engine control (DEEC) was installed in an F-16 aircraft and evaluated throughout the flight envelope. Aspects of engine operation evaluated included afterburner and dry power throttle transients, airstarts, secondary control mode operation, and maneuvering flight. The F100 DEEC was found to be a significant improvement over the production F100-PW-200. The afterburner envelope was expanded and blowouts and compressor stalls were eliminated. Dry power operation and engine response were comparable to the production engine. Airstart capability was enhanced by an expansion of the airstart envelope of 20 to 25 percent in airspeed. Secondary control mode airstart capability was similar to that in the production engine. Similarity in airstart procedures between primary and secondary mode was a major advantage. Secondary mode engine operation was generally satisfactory. Author

**A86-23350#**

### AIRCRAFT FUEL PUMP DESIGN

U. S. ROHATGI (Brookhaven National Laboratory, Upton, NY) IN: Design methods for two-phase flow in turbomachinery; Proceedings of the Mechanics Conference, Albuquerque, NM, June 24-26, 1985. New York, American Society of Mechanical Engineers (Fluid Engineering Symposia Series. FED Volume 26), 1985, p. 1-5. refs

A need to pump a mixture of two-phase fluid appears naturally in many situations. One example of this situation is aircraft fuel systems, where the pump inlet may have two-phase mixture due to the desorption of the dissolved gases at low pressures at higher altitudes. A procedure of selecting proper design conditions for the inlet inducer and a method of sizing the inducer, impeller and volute to meet all the design requirements has been described. This procedure has also been applied to a typical fighter plane boost pump design. Author

**A86-23506**

### DIGITAL CONTROL FOR ENGINE BLEED AIR

D. J. WIEMER (Sundstrand Aviation Mechanical, Rockford, IL) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 11 p.
(SAE PAPER 851316)

As modern control systems become more demanding and complex and the optimum control algorithm becomes more elusive, it becomes obvious that the versatility of control algorithm construction and modification in software is far superior to analog circuit implementations. A digital microprocessor based electronic control system has been developed for temperature control of engine bleed air on the B-1B bomber. The Engine Bleed Air Control System (EBACS) provides pressurized, temperature controlled air to various subsystems on the aircraft. This paper addresses the unique approach used in controlling a bleed air system having major gain variations (over 500 to 1) and major system-element time-constant variations (over 5 to 1) within the flight envelope, while still maintaining specified response times and stablity margins. Author

**A86-23664**

### THE EFFECT OF THE VELOCITY PROFILE AT THE DIFFUSER INLET ON THE FLOW PATTERN [VLIIANIE PROFILIA SKOROSTI NA VKHODE V DIFFUZOR NA KARTINU TECHENIIA]

A. M. TURILOV and G. M. SHALAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 70-74. In Russian. refs

Results of an experimental study of flow structure in the diffuser of a gas-turbine engine are presented for various types of nonuniform velocity profiles at the diffuser inlet. The changes in the mean and maximum jet characteristics along the diffuser length are examined. Results are presented in graphic form. V.L.

**A86-23670**

### EMISSION CHARACTERISTICS OF A SECTION OF THE COMBUSTION CHAMBER OF A GAS-TURBINE ENGINE WITH VARIOUS MODIFICATIONS OF THE BURNERS [EMISSIONNYE KHARAKTERISTIKI OTSEKA KAMERY SGORANIIA GTD S RAZLICHNYMI MODIFIKATSIIAMI GORELOCHNYKH USTROISTV]

F. M. VALIEV, A. V. TALANTOV, and V. A. SHCHUKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 91, 92. In Russian.

The paper reports the results of an experimental study of the emission characteristics of a 9-burner section of the combustion chamber of a gas-turbine engine. Results are reported for experimental and standard burners which differ in the method of air-fuel mixture preparation. It is shown that the use of experimental burners producing a mixture of prevaporized fuel partially mixed with air that is fed together with secondary air results in a decrease in HC and CO emission over the full range of stable combustion, with a certain increase in NO(x). In the case of lean mixtures, the use of the experimental burners improves the emission characteristics for all toxic gases. V.L.

**A86-23751**

### DIAGNOSTIC METHODS FOR GAS-TURBINE AIRCRAFT POWERPLANTS [DIAGNOSTICKE METODY LETECKYCH TURBINOVYCH JEDNOTEK]

S. SOUKUP Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 147-149. In Czech.

The potential of advanced in situ diagnostic techniques for increasing the reliability of gas-turbine aircraft powerplants is examined. The currently used diagnostic techniques are reviewed, with particular attention given to the continuous monitoring and recording of the operating parameters of the powerplant in flight. The prospects for adopting this approach for local commercial airlines is discussed. V.L.

**A86-23752**

### DETERMINATION OF DIAGNOSTIC PARAMETERS FOR THE IN SITU DIAGNOSTICS OF THE AIR-GAS PATH OF THE AI-25TL ENGINE [STANOVENIE DIAGNOSTICKYCH PARAMETROV PRE BEZDEMONTAZNU DIAGNOSTIKU VZDUCHO-PLYNOVEHO TRAKTU MOTORA AI 25 TL]

J. DULENCIN Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 151-156. In Slovak. refs

An approach is proposed for selecting diagnostic parameters for the in situ diagnostics of the air-gas path of the AI25TL jet engine. Use is made of tables of coefficients describing the effect of independent parameters on the dependent characteristics; also, a procedure for diagnosing the engine condition on the basis of the measured independent parameters is detailed. Finally, tables are presented for verifying the calculated coefficients against the measured parameters and simulated faults. V.L.

**A86-23753**

### SOUND GENERATION BY AN ENERGETICALLY INHOMOGENEOUS GAS FLOW IN A GAS-TURBINE AIRCRAFT ENGINE [GENERACE ZVUKU ENERGETICKY NEHOMOGENNIM PROUDEM PLYNU, KTERY PROTEKA TRAKTEM LETECKEHO TURBINOVEHO MOTORU]

F. KOPECKY Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 157-160. In Czech. refs

Mathematical models describing sound generation by an energetically inhomogeneous air flow issuing from a model of a gas-turbine aircraft engine into a quiescent ambient medium are examined. An aerodynamic installation is then briefly described which has been built for the experimental determination of the relationship between the degree of flow inhomogeneity and the parameters of the generated sound. V.L.

**A86-23754**

**SIMULATION OF THE VIBRATION TRANSMISSION PATH AND THE USE OF A MATHEMATICAL MODEL OF VIBRATION TRANSMISSION FOR THE VIBRATIONAL DIAGNOSTICS OF AN AIRCRAFT ENGINE [MODELOVANI PRENOSOVE CESTY VIBRACI A VYUZITI MATEMATICKEHO MODELU PRENOSU VIBRACI PRO VIBRODIAGNOSTIKU LETECKEHO MOTORU]**

D. KRENEK Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 161-164. In Czech. refs

A simplified model describing vibration transmission in a gas-turbine aircraft engine is presented which is based on the method of the initial flexural vibrations and on solving the motion transmission problem through an expansion in natural vibration modes. A software implementation of the vibration transmission model is briefly described, and some results are presented in the form of diagrams. V.L.

**A86-23756**

**A HOLOGRAPHIC STUDY OF THE VIBRATIONAL MODES OF AIRCRAFT ENGINE ROTORS [HOLOGRAFICKE VYSETROVANI TVARU KMITANI OBEZNYCH KOL LETECKYCH MOTORU]**

K. ANTROPIUS and A. PASLEROVA Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 173-177. In Czech. refs

The use of holographic interferometry for investigating the vibrational modes of aircraft engine components in general and rotors in particular is reported. Methods using time-averaged and additional exposures are briefly described; attention is also given to surface preparation procedures prior to holographic measurements and methods of resonance excitation. Sample interferograms of rotors and blades are presented. V.L.

**A86-23832#**

**AN EXPERIMENTAL INVESTIGATION OF RESPONSE OF A TURBOJET ENGINE TO INLET DISTORTION**

F. CHEN, W. LI, Z. WANG, and M. CONG (Northwestern Polytechnical University, Xian, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 5 p. refs
(ASME PAPER 85-IGT-12)

A study of the response of a turbojet engine to the steady-state and the turbulence-type dynamic inlet distortion is presented. The steady-state distortion is generated by a 180 deg extent, 36 mesh screen, and the turbulence-type dynamic distortion by a 180 deg extent plate with 50 percent blockage ratio at the engine face. This plate can produce a very strong pressure fluctuation at the engine face. Results from testing show: (1) inlet distortion generated by the screen will produce a classical-surge or deep-surge; (2) the degree of distortion by the screen can change the mode of surge, e.g. from the classical surge to the deep surge and vice versa; (3) both the inlet distortion and the decrease in first-stage-turbine-nozzle area will change the compressor performance maps; (4) the turbulence-type dynamic distortion causes a 'drift-surge'. Author

**A86-23853#**

**A COST-EFFECTIVE PERFORMANCE DEVELOPMENT OF THE PT6A-65 TURBOPROP COMPRESSOR**

T. YOSHINAKA and K. S. THUE (Pratt and Whitney Canada, Aerodynamics Dept., Longueil) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 9 p. refs
(ASME PAPER 85-IGT-41)

The largest member of the PT6 turboprop engine family, the PT6A-65, was developed in the early 1980's and went into production in September 1982. The compressor for this engine consisted of four new axial stages combined with an existing centrifugal stage on a single shaft. This paper gives a brief description of the studies leading up to the choice of the compressor configuration and a more detailed examination of the development of the chosen compressor to the required performance level. The development of this compressor presented a two-fold technical challenge. Firstly, the limited space in the small compressor gas path did not permit the effective use of conventional total pressure and temperature probes for performance evaluation. Secondly, the short time available for development excluded some attractive corrective measures such as the redesign of some of the axial blade rows because the time required would have jeopardized the meeting of the tight development deadline. The first problem was overcome by a combination of limited wall static pressure measurements and an extensive use of numerical flow analysis codes. This approach proved to be quite cost-effective. The second was solved by the adaptation of an existing fully analytically-designed research axial stage to the first stage position in the axial compressor. Author

**A86-23858#**

**METHOD OF SPARE PARTS - DIGITAL SIMULATION OF AIRCRAFT TURBINE ENGINE CONTROL SYSTEM**

Y.-S. GUAN, J.-S. WARNG, and T.-C. LEE (Northwestern Polytechnical University, Xian, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p. refs
(ASME PAPER 85-IGT-52)

The paper presents a new method of digital simulation of a control system. A computer program of an aircraft engine control system, as for an example, is implemented as a full authority digital simulator. The results of simulation show that the functions and applications of the simulator are extended as compared with those of the other type mathematical simulators. Author

**A86-23859#**

**OPTIMAL CONTROL CHANGE OF STATE OF AIRCRAFT TURBINE ENGINE**

T.-C. LEE and Y.-S. GUAN (Northwestern Polytechnical University, Xian, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p. refs
(ASME PAPER 85-IGT-53)

The paper presents the application of linear quadratic regulator theory to the control of change of state of an aircraft turbine engine from rated to maximum. On the basis of the engine digital simulator, an optimal regulator of change of state is designed. The results of simulation of the optimal control system show that: during transient processes, maximum rotor speed deviation is decreased from 148 rpm to 4.5 rpm, thrust settling time is shortened from 7 seconds to 4 seconds, and transient response of turbine outlet temperature is refined from small overshot to monotonic, as compared with the original hydromechanical control system; thus, the improvement is apparent. Author

**A86-23861#**

**DESIGN APPROACH FOR AN OPTIMUM PROP-FAN PROPULSION SYSTEM**

G. L. BRINES (United Technologies Corp., Pratt and Whitney Div., East Hartford, CT) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 6 p. refs
(ASME PAPER 85-IGT-57)

The predicted potential performance of the Prop-Fan offers a major improvement in the energy efficiency of future, short-range to medium-range transports. This paper describes the approach taken in designing an optimum Prop-Fan propulsion system. Trade-offs in the configuration(s) and performance are discussed, as are the important aspects of integrating the propeller, gearbox, engine, inlet, exhaust, and nacelle. Realizing the impressive potential fuel savings of the Prop-Fan will require very careful engine/airframe integration. Design options that will be compared are: a single-rotation versus counter-rotation arrangement, a tractor versus pusher installation, and wing versus fuselage mounting. In summary, the performance of turbofan powered and Prop-Fan powered, short-haul transports will be compared in detail by using fuel burn, operating costs, and noise as criteria. Author

**A86-23883#**

### CONVERGENCE OF PERFORMANCE CALCULATION OF TWIN SPOOL TURBOJET AND TURBOFAN

X. ZHU, X. WANG, and Q. YAN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(ASME PAPER 85-IGT-82)

A method of order-reduction for a multivariate nonlinear system used to calculate twin spool turbojet and turbofan performance is recommended. With the proper incorporation of other approaches, it can achieve satisfactory results in any flight condition and throttle setting. Compared with the experimentation data it can model the engine very well. Author

**A86-23884#**

### RAPID CALCULATION OF ENGINE PERFORMANCE

J. ZHANG and X. ZHU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 6 p.
(ASME PAPER 85-IGT-83)

A rapid calculation procedure for the design and off-design performance of turbojet and turbofan engines is developed. In the procedure, the general characteristics of components are established based on statistical data, and the engine working conditions are searched according to matching of these general characteristics. This method can be used to select cycle parameters in engine design, and has been employed in engine performance calculation program used in the prelimnary phase of engine design or airframe/engine integration design. Author

**A86-23888#**

### STATE OF THE ART IN AIRCRAFT GAS TURBINE TECHNOLOGY

S. R. SAMPL and M. E. SHANK (United Technologies Corp., Engineering Div., East Hartford, CT) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(ASME PAPER 85-IGT-87)

The new series of turbofan engines use advanced technology features which enhance their attractiveness through reductions in the cost of ownership, noise, and pollution. Improvements in aerodynamics, mechanics, electronics, and materials technology reduce the cost of ownership via such factors as cost, reliability, durability, and operability. Primarily, advanced technology addresses fuel consumption, a parameter with a very large effect on direct operating cost. In addition, these advances do not trade convenience of operation for environmental acceptability. The advanced technology concepts used in the new commercial aircraft turbine engines offer both economic and environmental benefits. Author

**A86-23899#**

### PREDICTION OF BLADE FLUTTER IN A TUNED ROTOR

J. XU and Z. SONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(ASME PAPER 85-IGT-100)

This paper is about blade flutter in a tuned rotor. With the aid of the combination of the three-dimensional structural finite element method, two-dimensional aerodynamic finite difference method, and strip theory, the quasi-steady models in which two degrees of freedom for a single wing were considered have been extended to multiple degrees of freedom for the whole blade in a tuned rotor. The eigenvalues solved from the blade motion equation have been used to judge whether the system is stable or not. The calculating procedure has been formed and, using it, the first stage rotating blades of a compressor where flutter had occurred, have been predicted. The numerical flutter boundaries are in good agreement with the experimental ones. Author

**A86-23912#**

### FURTHER APPLICATIONS OF THE LUCAS FAN SPRAY FUEL INJECTION COMBUSTION SYSTEM

E. CARR (Lucas Aerospace, Ltd., Combustion Technology and Engineering Centre, Burnley, England) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p.
(ASME PAPER 85-IGT-116)

An evaluation is made of the performance characteristics and design features of fan spray-type gas turbine combustor systems, with attention to a remotely piloted vehicle-engine application with combustion loadings five times greater than those of an initial application of the fan spray configuration. Results of flow visualization, combustion loading over a large air/fuel ratio range, and light-up under a wide range of simulated flight conditions, are presented for a total of six different fan spray combustor configurations. O.C.

**A86-23917#**

### GAS TURBINE COMBUSTION EFFICIENCY

B. SCHLEIN (United Technologies Corp., Pratt and Whitney Div., East Hartford, CT) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 6 p. refs
(ASME PAPER 85-IGT-121)

A method of correlating combustor efficiency as a function of geometry and operating conditions is presented. A simple equation correlates all the data for a given engine type with a single parameter. The correlating parameter is a function of fuel flow, pressure, temperature and volume in a form similar to others in the literature. The unique feature of the correlating parameter is its use of internal gas temperature rather than the commonly used combustor inlet temperature. The result is an equation requiring an iterative solution since combustion efficiency is a part of the correlating parameter. With use of a computer this is easily handled. The correlation fits engine data over all flight conditions from high altitude, high Mach number to sea level idle. The correlation is compared to engine test data for several engines. Author

**A86-23928#**

### LIFE PREDICTION FOR THE MAIN SHAFT OF AIRCRAFT TURBINE ENGINE

D. LIU (Chengdu Engine Co., People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p. refs
(ASME PAPER 85-IGT-136)

The life prediction of the main shaft is described herein at the following three aspects: estimation of the fatigue life, testing method of the fatigue life and determination method of the service life for the main shaft. Based on the working practice, a block diagram of life determinating procedure for the main shaft, from which the prediction contents and steps of the fatigue life for the main shaft can be seen, is also included. Since the factors affecting the fatigue life of hardwares are very complicated, so only the main factor can be taken into consideration in the method of prediction of the life. Therefore, the emphasis is given to the need for a life prediction computation program which integrates the main shaft design, testing and application, so that the computation theory of the whole life prediction can be established on the foundation of the test practice and service experience. The life of main shaft can be predicted by calculation during the design stage. The local stress method and strain empiric formula are applicable for the prediction of the main shaft life in its elastoplastic area. Author

**A86-23931#**

### DEVELOPMENT OF A NEW TECHNOLOGY SMALL FAN JET ENGINE

D. I. BOYD (Pratt and Whitney Canada, Longueuil) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p.
(ASME PAPER 85-IGT-139)

The JT15D Turbofan Engine was created to power fast economical low noise executive jets for the general aviation market and currently powers the Cessna Citation I and II, Mitsubishi Diamond series and the Aerospatiale Corvette. This paper describes a higher thrust more fuel efficient version, the JT15D-5, with electronic fuel control systems and power up to a thrust level of 3200 lb. The Engine and its development program are described, including flight test and customer installations. Development problems and their solutions are covered. Author

**A86-23938#**

### INVESTIGATION INTO THE CAUSE OF FAILURE OF A TURBOPROP IMPELLER IN SERVICE

H. Y. WONG (Glasgow, University, Scotland) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p.
(ASME PAPER 85-IGT-147)

A 2-stage centrifugal flow turboprop Dart engine failed recently in service due to the failure of the low pressure impeller. Examination by various techniques including electron microscopy based on scanning, energy dispersive analysis of X-ray and transmission electron fractography indicates that the cause was metallurgical in nature, resulting from a material manufacturing defect followed by fatigue fracture and finally by tensile rupture of the material. Author

**A86-23941#**

### PROPELLER DESIGN POINT CALCULATION METHOD FOR COMPARING TURBOFAN/PROPFAN ENGINE PERFORMANCE

M. F. SCHMIDT (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 11 p.
(ASME PAPER 85-IGT-150)

This paper presents a method for calculating the design-point performance of both single rotation and dual contrarotation propellers. Major propeller variables such as power loading, propeller efficiency, propeller tip speed, and propeller adiabatic compression efficiency, are accounted for and correlated. The resulting propeller performance is then combined with engine performance to yield propfan engine performance. The performance trades between power loading, propeller efficiency, propeller tip speed and propeller adiabatic compression efficiency are presented. Resulting performance for a given engine is presented for both single and dual contrarotation propellers. These engine performances can then be compared to advanced turbofan engines that utilize identical technology shaft power-producer engines. Author

**A86-24226#**

### THE FORCED RESPONSE OF SHROUDED FAN STAGES

C.-H. MENQ, J. H. GRIFFIN, and J. BIELAK (Carnegie-Mellon University, Pittsburgh, PA) ASME, Design Engineering Technical Conference, Cincinnati, OH, Sept. 10-13, 1985. 6 p. refs
(Contract AF-AFOSR-0134; F33615-83-K-2316)
(ASME PAPER 85-DET-19)

This paper presents a general approach for modeling shrouded blade vibration that takes into consideration the nonlinear friction constraint at the shroud interface. In this approach, linear structures are characterized by receptances and shroud constraints by nonlinear impedances. The proposed methodology is presented in detail for simplified models of the bladed disk and shroud interface. The corresponding governing equations for the dynamic response are derived for both tuned and mistuned stages. As an example the method is applied to an idealized tuned stage. Two cases are considered, a lubricated shroud for which the coefficient of friction is equal to zero, and a frictionally constrained shroud. The effect of varying the shroud-to-shroud preload is studied. In the lubricated case nonlinear behavior is seen when vibrations are strong enough to result in separation of the shroud interfaces. In the case of finite friction there is a profound change in resonant frequencies when the preload is increased sufficiently to prevent gross slip at the shrouds. Author

**A86-24712**

### EXCITATION OF BLADE VIBRATION BY FLOW INDUCED ACOUSTIC RESONANCES IN AXIAL-FLOW COMPRESSORS

R. PARKER, S. A. T. STONEMAN, and M. I. CARR IN: Unsteady aerodynamics of turbomachines and propellers; Proceedings of the Symposium, Cambridge, England, September 24-27, 1984 . Cambridge, Cambridge University, 1984, p. 579-600. Research supported by Rolls-Royce, Ltd. and SERC. refs

When operating below design speed, with resulting blade mismatching, there arises a hitherto unrecognized blade vibration phenomenon in research compressors used in aircraft engine research which is clearly associated with acoustic resonances in the compressor annulus. Attention is presently given to the results of theoretical and experimental investigations concerning the effects of compressor annulus shape, as well as those of fluidmechanical/acoustical interactions furnishing the excitatory mechanism. This mechanism is influenced by the acoustic characteristics of the annulus and by the frequency of vortex shedding, which locks onto one of the possible resonances. O.C.

**A86-24861**

**DESIGN AND DEVELOPMENT OF AN INERTIAL POWER SUPPLY UNIT FOR CARRIER-BASED AIRCRAFT**

R. HOCKNEY, SR., D. EISENHAURE, S. ODEA, B. JOHNSON, and R. MARIANO (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.343-2.348.

An inertial power supply unit with a design operating lifetime of 20,000 hrs has been designed and built to replace a high maintenance cost electric battery system currently powering carrier-based aircraft inertial navigation systems. This flywheel unit, which has the form, aircraft fit, and function characteristics of the battery it is replacing, offers (in addition to better maintenance costs) unlimited charge/discharge cycling, long shelf life, and the capacity for both state-of-charge and bearing condition monitoring. O.C.

**A86-25021**

**THE PROP-FAN INTRODUCES A NEW ENGINE GENERATION [DER PROPFAN LEITET EINE NEUE TRIEBWERKSGENERATION EIN]**

P. SCHIMMING (DFVLR, Institut fuer Antriebstechnik, Cologne, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 49-51. In German.

The increased importance of fuel costs with respect to the general operating costs of the airlines has led to the design of lighter and aerodynamically more favorable aircraft, and to the development of aircraft engines which consume less fuel. The development of the prop-fan in the U.S. during the early and mid-1970s led to the establishment of new engine concepts. The prop-fan itself is a propeller which has eight or more (as many as 12) blades. New design methods for these advanced propellers make it possible to obtain higher flight speeds at better propeller efficiencies than those provided by conventional propeller propulsion systems (turboprops). For this reason, prop-fan engines are becoming serious rivals of turbofan engines. Attention is given to propulsion system concepts for providing thrust, questions related to the selection of an engine for civil aviation, efficiency obtained on the basis of a design of propeller blades according to the newest aerodynamic viewpoints, and calculations for an engine design with minimum fuel consumption. G.R.

**A86-25177#**

**RESEARCH AND DEVELOPMENT OF FJR 710 TURBO FAN ENGINE - SECOND PHASE**

M. MATSUKI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 372, 1985, p. 12-19. In Japanese.

The construction, specification, and testing of the FJR 710 turbofan engine are described. The engine developed by the Research Association of Jet Engine Technology, Japan, will be tested with a STOL test aircraft. The basic engine parameters are fan pressure ratio of 1.45, overall pressure ratio of 19, turbine inlet temperature of 1250 C, and bypass ratio of 6.5 for reducing the fuel consumption. The schedule of the engine development including design, manufacturing, tests on performance and operation, and structural tests, such as static loading, blade containment, and overspeed and low cycle fatigue are illustrated. S.H.

**A86-25192#**

**EXPERIMENTAL STUDY OF THE EFFECTS ON THE TURBOFAN ENGINE BY THE DISTORTION**

T. ABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 374, 1985, p. 173-181. In Japanese, with abstract in English.

An experimental study was conducted to determine the effects of pressure distortion on the operation of a turbofan engine. In particular, the effects on the pressure ratio and efficiency of a two-stage axial flow fan and a five-stage axial flow compressor were studied. Two distortion indices on the orthogonal coordinate are indicated, and the circumferential distortion index is related to the radial distortion index. It is suggested that three kinds of distortion seem enough to cover all the distortion patterns encountered in flight. The pressure ratio and efficiency of a fan with distorted inflow decreased compared with those for clean inlet flow. However, the operation line and compressor efficiency hardly suffered from the distortion. C.D.

**A86-25201#**

**AN ANALYTICAL METHOD OF THE CHARACTERISTICS OF THE TURBOFAN ENGINE COMPONENTS**

T. ABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 376, 1985, p. 303-311. In Japanese, with abstract in English. refs

This paper presents an analytical method to estimate accurately the compressor air mass flow rates an high pressure turbine inlet temperature of a two-spool turbofan engine on the basis of the characteristics of a high-pressure turbine and a combustor. The off-design performance was used as the characteristic of a high-pressure turbine. The pressure loss rates and the combustion efficiency were selected as the characteristics of a combustor. The off-design performance was analyzed from the total pressure loss coefficient analysis of the stator and the blade, and design data. The proposed method was applied to a low bypass ratio two-spool turbofan engine and compared with the model compressor test data. The results proved to be useful for estimating turbofan-engine component performance. Author

**A86-25219#**

**VIBRATION PROBLEMS OF JET ENGINE ROTOR SYSTEMS**

T. MIYACHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 379, 1985, p. 439-446. In Japanese. refs

The characteristics of turbo and jet engine rotor systems and problems in their vibrations, and their countermeasures are described. Various possibilities of the vibration of the turbo engine rotor system are analyzed. The control methods of the vibration of the jet engine rotor system characterized include trim balance of the rotor during manufacturing, spectrometric oil analysis program and condition maintenance for monitoring the vibration of the rotor in flight, active clearance control using a full-authority digital engine control method, and a balancing method of the impulse of the rotor. S.H.

**A86-25234#**

**A STUDY OF RAMJET ENGINE. III - AIR INLET PERFORMANCE AS THE ENGINE COMPONENT**

K. FUNAKI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 381, 1985, p. 584-591. In Japanese, with abstract in English. refs

A computer program was developed for computing the performance of a fixed-geometry two-dimensional external compression supersonic ramjet-engine inlet, which permits the required air mass flow rate for the engine to operate at off-design conditions. The program can compute the quantity of possible air flow coming through the inlet under critical operating conditions as well as the required air flow for the ramjet engine to generate the combustion gas that will be exhausted through a jet nozzle of the engine operating under given engine conditions and critical air inlet operation. A correlation between the exponential function of the flight and design Mach numbers, and the gas properties was found, which makes it possible to predict the pressure recovery in a supercritical regime. The correlation was found to be in good agreement with the available experimental data on ramjet engines. Author

**A86-26071#**

**FLAT RATING CONCEPT INTRODUCED IN THE GTX ENGINE**

A. PRASAD and V. SUNDARARAJAN (Gas Turbine Research Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 35, April 1985, p. 163-170.

In bypass engines, the loss of thrust increases with increase in the inlet total temperature. The concept of variable cycle, achieved by varying the maximum cycle temperature in order to increase the available dry thrust, is explained, together with its application to the GTX 37-14U engine design. The design principles of the GTX engine, which is a twin spool turbojet with a throttle ratio of 1.13 are briefly described and the engine performance at 288 K and 318 K is compared to that of a conventional design with a throttle ratio of unity. The variable cycle concept is presently recognized in the design of engines for combat aircraft, designed for supersonic cruise at altitude. Graphs of the performance analysis are included. I.S.

**A86-26154#**
**THE RELATIONSHIP OF ULTRAFINE FILTRATION AND OIL DEBRIS MONITORING FOR HELICOPTER PROPULSION SYSTEMS**
T. TAUBER (Technical Development Co., Glenolden, PA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 13 p. refs

Research data indicate that rolling-element bearing life can be extended considerably by improving lubricant filtration. It is pointed out that disposable ultrafine oil filters with ratings better than 7 micrometers absolute have been commercially available for some time and are being used in several helicopter engines. In the past, helicopter drive systems have been equipped with relatively coarse filters. The U.S. Army has conducted an extensive evaluation of ultrafine filters and advanced oil debris monitoring technology between 1978 and 1983. The test fleet was retrofitted with an advanced Oil Debris Detection System (ODDS). The U.S. Army ODDS program is discussed, taking into account splash-type vs. full-flow chip detection, component wear, and debris. The program demonstrated that failure progression of any component occurs over a considerably longer period of time than any one particular flight. G.R.

**A86-26156#**
**T700 - A PROGRAM DESIGNED FOR EARLY MATURITY AND GROWTH POTENTIAL**
E. E. MARTIN (General Electric Co., Turboshaft Engine Projects Dept., Lynn, MA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p. refs

Work related to the development of an advanced turboshaft engine to be used in a utility type of helicopter was started by an American aerospace company in the 1960s. This engine, which later became the T700, was to provide a replacement for the T58, a successful but aging helicopter powerplant which originated in the 1950s. The U.S. Army needed a turboshaft engine with greatly improved capability relative to previous generation machines for its helicopters, and the T700 was developed to meet these requirements. Currently three turboshaft engine models have been qualified to power six military aircraft versions, while three turboshaft and two turboprop versions have been certificated for application on six civil aircraft. G.R.

**N86-19323#** Eidgenoessisches Flugzeugwerk, Emmen (Switzerland). Research and Testing Dept.
**PERFORMANCE COMPUTATION OF TURBOFAN AND TURBOJET ENGINES IN OFF-DESIGN CONDITIONS**
G. BRIDEL 11 Oct. 1984 28 p refs In GERMAN; ENGLISH summary
(F+W-FO-1746) Avail: NTIS HC A03/MF A01

A prediction method of underload performance of turbojet and turbofan engines based on gas dynamic relations was developed using mass flow rate, compression ratio, turbine inlet temperature, thrust, and fuel consumption. More precise prediction results can be obtained by incorporating compressor efficiency. A BASIC computer program is described and results are compared with existing data. Up to a throttling coefficient of 50% of the maximum thrust, the deviation with respect to the measured values falls within + or - 20%. The specific fuel consumption is improved in underload medium range but is increased at high throttling coefficients. Accuracy improvement is achieved with introduction of variable compressor and turbine efficiency. Author (ESA)

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-23186*#** Princeton Univ., N. J.
**LONGITUDINAL FLYING QUALITITES CRITERIA FOR SINGLE-PILOT INSTRUMENT FLIGHT OPERATIONS**
A. BAR-GILL (Rafael Armament Development Authority, Haifa, Israel) and R. F. STENGEL (Princeton University, NJ) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 111-117. Previously announced in STAR as N83-30407. refs
(Contract NAS1-15864; NGL-31-001-252)

Modern estimation and control theory, flight testing, and statistical analysis were used to deduce flying qualities criteria for General Aviation Single Pilot Instrument Flight Rule (SPIFR) operations. The principal concern is that unsatisfactory aircraft dynamic response combined with high navigation/communication workload can produce problems of safety and efficiency. To alleviate these problems, the relative importance of these factors must be determined. This objective was achieved by flying SPIFR tasks with different aircraft dynamic configurations and assessing the effects of such variations under these conditions. The experimental results yielded quantitative indicators of pilot's performance and workload, and for each of them, multivariate regression was applied to evaluate several candidate flying qualities criteria. S.L.

**A86-23346#**
**A STABLE DISCRETE-TIME ADAPTIVE OBSERVER APPLIED TO MULTIVARIABLE AIRCRAFT**
P. N. NIKIFORUK, N. HORI (Saskatchewan, University, Saskatoon, Canada), and K. KANAI (Defense Academy, Yokosuka, Japan) IN: Dynamic systems: Modelling and control; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 189-194. refs

The parameters and state variables of an unknown aircraft are estimated using an adaptive observer which is applicable to multivariable systems expressed in block observer form. The observer used is a simple extension of the single-variable situation to the multivariable case and requires neither the decomposition nor cyclicity of the system. This may make the design of a flight control system which needs the parameters and state vector of the aircraft as simple as one for single-variable systems. The results of simulation studies are given for the T-2 CCV with particular reference to the longitudinal aircraft motions. Author

**A86-23771**
**THE USE OF ANALYTICAL METHODS TO ASSESS AIRCRAFT MANEUVERABILITY [VYUZITI ANALYTICKYCH PRISTUPU PRO POSOUZENI MANEVROVACICH SCHPNOSTI LETOUNU]**
J. SALGA and J. SVEDA Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 333-340. In Czech. refs

The equations of motion of an aircraft as a mass point are used to express the characteristics of three maneuvers: straight flight with acceleration, unsteady horizontal turn, and combat turn with variable energy. The actual aircraft is included in the calculation through the mean values of attainable overloads. Graphs of a general applicability are presented. B.J.

**A86-23781**

**PROBLEMS IN RUDDER DESIGN FOR SMALL TRANSPORT AIRCRAFT [PROBLEMATIKA NAVRHU SMEROVEHO RIZENI U MALEHO DOPRAVNIHO LETOUNU]**

M. PESAK Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 403-407. In Czech.

The design of a rudder for use on a small transport aircraft manufactured in Czechoslovakia is described. In the design of the rudder, particular attention was given to case of flight with one inoperative engine, where the rudder has to counteract a considerable yawing moment due to thrust asymmetry. B.J.

**A86-24148**

**FREQUENCY METHODS OF AIRCRAFT IDENTIFICATION [CHASTOTNYE METODY IDENTIFIKATSII LETATEL'NYKH APPARATOV]**

L. M. BERESTOV, B. K. POPLAVSKII, and L. IA. MIROSHNICHENKO Moscow, Izdatel'stvo Mashinostroenie, 1985, 184 p. In Russian. refs

Mathematical models describing the motions of aircraft are reviewed, and methods for the experimental determination of the frequency characteristics of aircraft are discussed. Computational schemes for determining the parameters of the mathematical models from the frequency characteristics are presented which are based on an analysis of the amplitude-phase characteristics and balancing relationships. The accuracy of identificaton and the adequacy of the mathematical models are evaluated. V.L.

**A86-24577#**

**THE STUDY OF ADAPTIVE CONTROL AUGMENTATION SYSTEM IMPLEMENTED WITH MICROCOMPUTER**

W. WANG and S. XIAO Northwestern Polytechnical University, Journal, vol. 4, Jan. 1986, p. 23-33. In Chinese, with abstract in English. refs

The Hartmann and Drebs (1980) longitudinal adaptive control augmentation system neglected the influence of actuator dynamics, whihc is presently considered as a first-order inertial block. A simple but useful Kalman filter-based model for parameter estimation is also proposed through which computational requirements are decreased to 50 percent of the original. Attention is given to the microcomputer implementation of the scheme proposed; in order to satisfy real time criteria, the software employs module-structure fixed point operation and machine language. O.C.

**A86-24588**

**PROPOSAL FOR THE CHOICE OF STATE VARIABLES FOR EQUATIONS OF MOTION OF AIRCRAFT IN MOVING AIR [EIN VORSCHLAG FUER DIE WAHL DER ZUSTANDSVARIABLEN IN DEN BEWEGUNGSGLEICHUNGEN VON FLUGZEUGEN UNTER WINDEINFLUSS]**

R. BROCKHAUS (Braunschweig, Technische Universitaet, Brunswick, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, Nov.-Dec. 1985, p. 376-382. In German. refs

An attempt is made, by the exact definition of state variables for longitudinal and lateral motion, to achieve a more complete coupling between aircraft motion and wind. In addition to using the previously introduced wind angles alpha(W) and beta(W), two additional angles alpha(K) and beta(K) are introduced as 'inertial' components of the angles of incidence and sideslip. These new angles are defined using a series of Eulerian angles between flight path and body-fixed coordinates. The use of these variables in the equations of motion demonstrate the advantages of selecting them as state variables. The effect of wind motion on the aircraft is clarified thereby. C.D.

**A86-24633#**

**THE EFFECTIVENESS OF VARIOUS CONTROL SURFACES IN QUASI-STEADY AND UNSTEADY FLOWS - APPLICATIONS [EFFICACITE DE DIFFERENTES SURFACES DE CONTROLE EN QUASI-STATIONNAIRE ET INSTATIONNAIRE - APPLICATIONS]**

R. DESTUYNDER (ONERA, Chatillon-sous-Bagneux, France), R. BARREAU (Aerospatiale, Toulouse, France), and G. ANDERS (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) (NATO, AGARD, Meeting, 61st, Oberammergau, West Germany, Sept. 8-13, 1985) ONERA, TP, no. 1985-147, 1985, 69 p. In French. refs

(ONERA, TP NO. 1985-147)

Two large-scale half-models fitted with unsteady pressure sensors and static pressure taps were employed to study the effectiveness of various active control surfaces such as those being installed on modern transport aircraft. The studies covered the performances of spoilers with and without slots, flaperons, ailerons and trailing edge flaps and combinations of each from Mach 0.5 up to transonic speeds. A database was developed for defining semi-empirical corrections to models for the lifting and moment values for the control surfaces. Vibrations were induced using hydraulic actuators which induced rotations of up to 400 deg/sec, thereby imparting white noise over the 0-30 Hz range, harmonics, and pitching from 135-270 deg/sec. Angles of attack from -2 to +7 deg were examined, along with severe wing deflection. The excitations and data collection were entirely computer-controlled. Spoilers, which exhibited sufficient promise to encourage their continued development, were particularly effective when more than one were used. Additivity was also observed when flaperons were installed, provided an adaptive control law was defined for their use. M.S.K.

**A86-25203#**

**DEEP STALL CHARACTERISTICS OF THE MU-300**

T. HANAI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 377, 1985, p. 322-325. In Japanese. refs

The deep stall characteristics of the MU-300 Diamond aircraft are described. The MU-300 obtained type certificates from FAA in 1981, and from Canada, West Germany, and England in 1983, and has achieved a high angle of attack. The aerodynamic design, structural dimension, and flight test of the MU-300 are described. S.H.

**A86-25204#**

**AERODYNAMIC CHARACTERISTICS OF GENERAL AVIATION AT HIGH ANGLE OF ATTACK WITH THE PROPELLER SLIP STREAM**

N. MATSUO and S. HIRANO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 377, 1985, p. 326-332. In Japanese. refs

The aerodynamic characteristics of the FA-300 business aircraft at high angle of the attack with the propeller stream are described. The FA-300 offers two types, FA-300-700 for 340 HP, and -710 for 450 HP of the engine. The effects of the propeller slipstream on the high angle of the attack are discussed. S.H.

**A86-25205#**

**STALL FLUTTER OF HELICOPTER BLADE**

H. OKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 377, 1985, p. 332-339. In Japanese. refs

The characteristics of dynamic stall and its effects on helicopters are discussed. The type of the dynamic stall, and the effects of the Reynolds number, Mach number, average angle of attack, vibration number, and the airfoil type on the dynamic stall are discussed. The calculation methods of the stall flutter, such as pitch damping method and aerodynamic simulation technique, and characteristics of the helicopter airfoil are analyzed. S.H.

**A86-25213#**
**TRENDS OF ACTIVE CONTROL TECHNOLOGY**
K. KANAI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 378, 1985, p. 391-398. In Japanese. refs

The characteristics of active control technology (ACT) are compared with the conventional control method in relation to the design of a unified flight control system. The advantages and performance characteristics of reconfigurable and restructurable systems of flight control are analyzed. The design method of the control configured vehicle (CCV) on the basis of the ACT is described. The applications of the ACT to the Advanced Fighter Technology Integration/F-16 control system and the CCV-104G aircraft are discussed. S.H.

**A86-26136#**
**HELICOPTER ACTIVE CONTROL WITH BLADE STALL ALLEVIATION MODAL CAPABILITY**
A. DANESI (Roma, Universita, Rome, Italy) and A. DANESI (Selenia-Industrie Elettroniche Associate, S.p.A., Pomezia, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 19 p. refs

An active modal control for high-performance helicopters in forward flight is presented. A blade stall alleviation control strategy based on the spectral data computed from the flexible blade structural mode of vibration measurements is employed to suppress the blade torsional motion associated with the stall flutter and to reduce the possibility of high angle of attack onset on the retreating blade. The restoring collective pitch commands are derived for processing the output data from an electrooptical laser sensor by means of a microprocessor performing the power spectral density real time computations; these data, obtained implementing an FFT algorithm and observed within a frequency window centered at the dominant torsional mode frequency, are employed as a measure of the actual vibrational level existing on the blade. An optimal control strategy is implemented in order to release the blade loads below the critical limits predicted for the blade stall onset. Author

**A86-26147#**
**DFVLR FLYING QUALITIES RESEARCH USING OPERATIONAL HELICOPTERS**
H.-J. PAUSDER and K. SANDERS (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 16 p. refs

A flight test program has been conducted in the field of flying qualities research. The tests utilized the operational helicopters BO 105 and UH-1D of the DFVLR and the German Flight Test Center. The main advantage of operational helicopters is the reality of visual and motion cues for the pilot. The extensive flight tests had the objectives: (1) to assess the demands of missions, (2) to derive qualified flight test tasks, (3) to determine criteria for task performance evaluation, and (4) to establish anchorpoints for an examination of validity of a simulator results. An overview of the DFVLR test activities is presented. Exemplary results for each objective are shown. A definition of agility demands for missions and a task performance evaluation approach for 'dolphin' and 'slalom' are discussed. Author

**A86-26160#**
**HELICOPTER MANEUVRE STABILITY - A NEW TWIST**
M. R. SWALES and A. W. DEBUSE (Empire Test Pilots' School, Boscombe Down, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p. refs

Modern helicopters, with their wide maneuver and speed envelopes, need to have their maneuver stability carefully assessed using up to date techniques which set realistic limits, easily respected by operational pilots. The phenomenon of maneuver stability is explained in theory and practice with a brief discussion on the classical flight test methods used in the past to establish acceptability criteria for a helicopter's maneuver stability. This approach is then extended to encompass modern helicopters capable of high sustained turn rates, negative g, having sophisticated automatic flight control systems, hingeless rotors, and the tandem rotor configuration. Modern maneuver stability flight test techniques which are taught to student helicopter test pilots are described with recommendations from typical flight test results including maneuver limitations and methods of communicating them to the helicopter pilot. Author

**A86-26170*#** Massachusetts Inst. of Tech., Cambridge.
**HELICOPTER ATTITUDE STABILIZATION USING INDIVIDUAL-BLADE-CONTROL**
N. D. HAM (MIT, Cambridge, MA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 7 p. NASA-sponsored research. refs

A theoretical study is presented on the application of the Individual-Blade-Control concept to helicopter attitude stabilization. The design of a system controlling blade flapping dynamics, and related testing of the system on a model rotor in the wind tunnel, is described. The control inputs considered are blade pitch changes proportional to blade flapping acceleration, velocity, and displacement. The effect of such a system on helicopter rotor damping-in-pitch, and angle-of-attack stability is then evaluated. It is shown that helicopter attitude stabilization is achieved, with a corresponding improvement in flying qualities. R.R.

**N86-19324*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**COMPARISON OF PILOT EFFECTIVE TIME DELAY FOR COCKPIT CONTROLLERS USED ON SPACE SHUTTLE AND CONVENTIONAL AIRCRAFT**
C. M. PRIVOZNIK and D. T. BERRY Feb. 1986 20 p refs
(NASA-TM-86030; H-1222; NAS 1.15:86030) Avail: NTIS HC A02/MF A01 CSCL 01C

A study was conducted at the Dryden Flight Research Facility of NASA Ames Research Center (Ames-Dryden) to compare pilot effective time delay for the space shuttle rotational hand controller with that for conventional stick controllers. The space shuttle controller has three degrees of freedom and nonlinear gearing. The conventional stick has two degrees of freedom and linear gearing. Two spring constants were used, allowing the conventional stick to be evaluated in both a light and a heavy configuration. Pilot effective time delay was obtained separately for pitch and roll through first-order, closed-loop, compensatory tracking tasks. The tasks were implemented through the space shuttle cockpit simulator and a critical task tester device. A total of 900 data runs were made using four test pilots and one nonpilot (engineer) for two system delays in pitch and roll modes. Results showed that the heavier conventional control stick had the lowest pilot effective time delays. The light conventional control stick had pilot effective time delays similar to those of the shuttle controller. All configurations showed an increase in pilot effective time delay with an increase in total system delay. Author

**N86-19325*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**FLIGHT TEST OF A RESIDENT BACKUP SOFTWARE SYSTEM**
D. A. DEETS, W. P. LOCK, and V. A. MEGNA (Draper (Charles Stark) Lab., Cambridge, Mass.) Jan. 1986 12 p refs Submitted for publication
(NASA-TM-86807; H-1338; NAS 1.15:86807) Avail: NTIS HC A02/MF A01 CSCL 01C

A new fault-tolerant system software concept employing the primary digital computers as host for the backup software portion has been implemented and flight tested in the F-8 digital fly-by-wire airplane. The system was implemented in such a way that essentially no transients occurred in transferring from primary to backup software. This was accomplished without a significant increase in the complexity of the backup software. The primary digital system was frame synchronized, which provided several advantages in implementing the resident backup software system. Since the time of the flight tests, two other flight vehicle programs have made a commitment to incorporate resident backup software similar in nature to the system described in this paper. Author

**N86-19326#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**DETERMINATION OF PERFORMANCE AND STABILITY CHARACTERISTICS FROM DYNAMIC MANEUVERS WITH A TRANSPORT AIRCRAFT USING PARAMETER IDENTIFICATION TECHNIQUES**

J. H. BREEMAN, L. J. J. ERKELENS, and A. M. H. NIEUWPOORT 14 Mar. 1984 23 p refs Presented at AGARD Flight Mechanics Panel Symposium on Flight Test Technology, Lisbon, Portugal, 2-5 Apr. 1984
(Contract NIVR-1816)
(NLR-MP-84024-U; B8572246) Avail: NTIS HC A02/MF A01

A flight test program was executed with the Fokker F28 transport aircraft to investigate whether it is possible to determine performance and stability characteristics from dynamic maneuvers using parameter identification techniques, with sufficient accuracy for certification purposes. A research moving base flight simulator was used to select an optimal set of maneuvers. Flight test data was analyzed, using the two-step method which starts by reconstructing the aircraft flight path as the first step, followed by calculation of aerodynamic coefficients using regression analysis techniques. The flight test results compared with results derived from conventional test programs show that the goal is reached. Author (ESA)

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-23187#**

**WIND TUNNEL WALL INFLUENCE CONSIDERING TWO-DIMENSIONAL HIGH-LIFT CONFIGURATIONS**

T. E. LABRUJERE, R. A. MAARSINGH, and J. SMITH (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) (ICAS, Congress, 14th, Toulouse, France, Sept. 9-14, 1984, Proceedings. Volume 1, p. 76-84) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 118-125. Previously cited in issue 22, p. 319, Accession no. A84-44935.

**A86-23189*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMPOSITE STATISTICAL METHOD FOR MODELING WIND GUSTS**

J. R. SCHIESS (NASA, Langley Research Center, Hampton, VA) (Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers, p. 62-68) Journal of Aircraft (ISSN 0021-8669), vol. 23, Feb. 1986, p. 131-135. Previously cited in issue 19, p. 2843, Accession no. A85-40562. refs

**A86-23265**

**AN IMPROVED SMOKE GENERATOR FOR AIRCRAFT TESTING**

E. H. SHELBOURN (Douglas Aircraft Co., Long Beach, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 14-1 to 14-4.

An improved smoke generator is described for on-aircraft testing of smoke detection systems and smoke clearing and penetration rates. A heater is added to an existing smoke generator in order to produce smoke that more realistically simulates real fire conditions. Tests demonstrated significantly earlier detection than with the unmodified generator. Author

**A86-23380**

**NEW NOSE-IN AIRCRAFT GUIDANCE/DOCKING SYSTEM DEVELOPED**

J. B. AMORETTI (Ugec, Paris, France) ICAO Bulletin, vol. 40, Dec. 1985, p. 32-34.

The development of the ground guidance and docking system UCRAFT for Charles de Gaulle International Airport is described. The system, using robotic techniques, is designed for platforms with a nose-in system and platforms which already contain an optical sight guiding system. The ICAO requirements and pilot recommendations for the design of the guidance and docking system are examined. The advantages UCRAFT provides for its users are discussed. I.F.

**A86-23750**

**SIMULATOR DESIGN FEATURES FOR HELICOPTER LANDING ON SMALL SHIPS**

D. P. WESTRA and G. LINTERN (Essex Corp., Orlando, FL) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1984, p. 1018-1022. refs

The role of helicopters in the U.S. Navy has considerably increased in recent years, and many Navy vessels support helicopters. The problems which arise in general in connection with aircraft operations at sea are aggravated on small ships because of the confined landing area and the instability of the deck. The present paper is concerned with an experiment which initiates research at the Naval Training Equipment Center's Visual Technology Research Simulator (VTRS) into simulator design and use in teaching essential flight control skills for helicopter operations from small ships. The reported experiment investigates the performance of eight experienced pilots in the simulator. The obtained results will be used to aid in the design of future transfer-of-training experiments to ultimately determine design requirements for simulators used to train the task of landing helicopters on small ships at sea. G.R.

**A86-23773**

**FLIGHT-MECHANICS PROBLEMS SOLVABLE BY A RESEARCH FLIGHT SIMULATOR [ULOHY Z MECHANIKY LETU RESENE NA VYZKUMNEM LETOVEM SIMULATORU]**

V. TICHOPAD Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1985, p. 345-348. In Czech. refs

The use of research flight simulators to solve various design and research problems in flight mechanics is examined. Typical examples of such problems are reviewed, and the possibilities of solving them with the research flight simulator of the Czechoslovak Aeronautical Research and Test Institute are discussed. B.J.

**A86-23845#**

**DISCUSSION ABOUT DYNAMIC SIMULATION TEST OF AN AERO-ENGINE CONTROL SYSTEM**

C. H. WU and D. FAN (Northwestern Polytechnical University, Xian, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 4 p.
(ASME PAPER 85-IGT-30)

A discussion is conducted concerning the features and performance capabilities of hybrid, physical/digital methods of aircraft engine control system simulation. Attention is given to an illustrative implementation of such a simulation system encompassing real aircraft engine control systems, a mathematical model of the engine in computer code form, and 'transformer' interfaces between the control apparatus and the computer code, taking the forms of an electric motor/generator, a low inertia electric motor, or a hydraulic pump/motor. O.C.

**A86-24638#**
**OPTICAL FIBERS APPLICATION TO VISUALIZATION OF FLOW SEPARATION INSIDE AN AIRCRAFT INTAKE IN WIND TUNNEL**
M. PHILBERT, R. DERON, J.-P. FALENI, J.-B. BION, and H. SALAUE (ONERA, Chatillon-sous-Bagneux, France) (SPIE - The International Society for Optical Engineering and Association Nationale de la Recherche Technique, International Symposium on Optical and Electro-Optical Applied Science and Engineering, 2nd, Cannes, France, Nov. 25-Dec. 6, 1985) ONERA, TP, no. 1985-158, 1985, 8 p. refs
(ONERA, TP NO. 1985-158)

An experiment visualizing air flow separation in an aircraft air-intake is presented. This experiment was realized in a large industrial wind-tunnel. It uses optical fibers to bring a laser beam into the model, and an optical fiber endoscope to visualize images of the phenomenon. Some pictures showing changes of the air flow separation are presented for several aerodynamic conditions. Author

**A86-24726**
**AERODYNAMIC TESTING CONFERENCE, 14TH, WEST PALM BEACH, FL, MARCH 5-7, 1986, TECHNICAL PAPERS**
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 419 p. For individual items see A86-24727 to A86-24765.

The present conference on aerodynamic testing apparatuses and methods considers current and planned wind tunnel capabilities at NASA Lewis, the estimation of unsteady forces on a cascade in three-dimensional turbulence, the test methods of the NASA Langley 0.3-m transonic cryogenic wind tunnel, testing experience at the National Transonic Facility, computational fluid dynamics code verification, progress with the NASA Lewis Altitude Wind Tunnel modeling program, the NASA Langley low turbulence pressure and supersonic low disturbance wind tunnels, and the effects of compressibility and freestream turbulence on boundary layer transition in high subsonic and transonic flows. Also discussed are the 'continuous sweep' pressure prediction technique, supersonic wind tunnel optimization, flexible wall nozzle design, hover-in-ground-effect testing for a full scale tilt-nacelle V/STOL model, accuracy in force testing in cryogenic wind tunnels, and experiments with a high performance canard airfoil with boundary layer trip and vortex generators. O.C.

**A86-24739#**
**THE ROLE OF WIND TUNNEL TESTING IN FUTURE AIRCRAFT DEVELOPMENT**
V. F. MEZNARSIC (McDonnell Aircraft Co., St. Louis, MO) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 127-133.
(AIAA PAPER 86-0750)

An assessment is made of various factors affecting the aerodynamic configuration development and wind tunnel testing of advanced fighter aircraft, with attention to such techniques as the use of low cost models during the conceptual design phase for high angle-of-attack stability and control trend evaluation, as well as the use of large scale, low speed models for refined development work in the high angle-of-attack regime. Design features and functions are noted for a powered model support whose blockage is comparable to that of an unpowered support, and a high speed swept blade support strut that eliminates aft end distortion problems common with sting installations. Flow visualization techniques employing flat sheet laser illumination have also been developed. O.C.

**A86-24740#**
**FUTURE REQUIREMENTS OF WIND TUNNELS FOR AERONAUTICAL SYSTEMS DEVELOPMENT**
M. L. BUCK and T. R. SIERON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 134-140. refs
(AIAA PAPER 86-0751)

This paper explores the requirements for future wind tunnels based on an assessment of the performance capabilities and goals of advanced aerospace vehicles. Conventional fighters, bombers, transports and special purpose vehicles are considered. In addition, operational environments are postulated for hypervelocity vehicles. Typical flight corridors are shown with the associated flow density, such as, real gas effects, low density flow, and nonequilibrium flow. An evaluation of the flight regimes and consideration of the operational requirements provides the insight for identifying future wind tunnel requirements. The area where the most serious testing deficiencies exist is at hypersonic speeds. Several types of hypersonic facilities are outlined which could provide critical wind tunnel data for the development of future hypervelocity vehicles. An observation is made that Computational Fluid Dynamics will require wind tunnel data to define detailed flow phenomena and to provide validation and guidance on flow modeling. Author

**A86-24742#**
**FUTURE REQUIREMENTS OF WIND TUNNELS FOR CFD CODE VERIFICATION**
C. W. BOPPE (Grumman Aerospace Corp., Aircraft Systems Div., Bethpage, NY) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 160-172. refs
(AIAA PAPER 86-0753)

Merit of Computational Fluid Dynamics (CFD) in the aircraft development process is measured by the degree to which flight characteristics can be simulated for advancing performance and/or improving flight safety. Unfortunately, elements of flight instrumentation and testing compromise the data required for computational flow simulation code development and verification efforts. Wind tunnel data satisfy this requirement to a large extent, but care must be taken to properly account for idiosyncrasies associated with subscale testing. Clearly, any facility feature which improves ability to simulate flight characteristics will favorably impact data taken for CFD code verification. In addition, however, a need for higher density in data resolution is identified. Technology exists to resolve current constraints, but it is not clear that means can be implemented in a cost-effective manner or that multiple problems can be resolved simultaneously. Several case studies are described which highlight future test requirements for code validation. The appendix describes several CFD/wind tunnel/flight test comparisons. Author

**A86-24746#**
**DYNAMIC SUPPORT INTERFERENCE IN HIGH ALPHA TESTING**
L. E. ERICSSON and J. P. REDING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 203-214. refs
(AIAA PAPER 86-0760)

Dynamic test results of aircraft models at high angles of attack are analyzed in regard to support interference effects. Single degree of freedom oscillatory tests in pitch or yaw are subject to the same type of support interference through the near wake recirculatory region as is experienced by slender bodies of revolution. Consequently, the measurements can be corrected for support interference using the same methodology. The support interference associated with rotary rigs used in coning experiments is of a different type, being stationary in nature rather than unsteady, with the coning motion inducing a displacement of the vortex wake similar to that caused by sideslip in a static test. Performing static tests at varying incidence and sideslip angles with two alternate supports can provide the information needed to correct coning experiments for support interference. Author

**A86-24756*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SOME LESSONS LEARNED WITH WIND TUNNELS**

M. L. SPEARMAN (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 316-326. refs
(AIAA PAPER 86-0777)

An historical evaluation is made of the most significant developments in the use of wind tunnels for the development and analysis of missiles and aircraft since the 1940s. In addition to being instrumental in the discovery of unknown aerodynamic, aeroelastic and aerothermodynamic phenomena, wind tunnels have helped in the explanation of numerous effects, the development of new configurations and systems, and the furnishing of critical initial performance evaluations for a broad spectrum of aircraft and missiles. Attention is given to low speed planform tests, body-wing-tail studies, variable sweep wing investigations, transonic characteristics and problems, supersonic trim drag, and supersonic pitch-up, area ruling, and inlet effects. O.C.

**A86-24765#**

**THE ACCURACY PROBLEM OF AIRPLANE DEVELOPMENT FORCE TESTING IN CRYOGENIC WIND TUNNELS**

B. EWALD (Darmstadt, Technische Hochschule, West Germany) and G. KRENZ (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: Aerodynamic Testing Conference, 14th, West Palm Beach, FL, March 5-7, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 405-415.
(AIAA PAPER 86-0776)

The measurement accuracy attainable in wind tunnel testing is limited by tunnel flow quality, model quality, and balance accuracy. It is presently noted that considerable accuracy improvements are obtainable through the use of large wind tunnel models and careful adaptation of the balance ranges to the test requirements. The primary uncertainty in balance measurements is due to thermal effects in the balance that are considerably exacerbated by cryogenic wind tunnel conditions. Attention is presently given to cryogenic balance development efforts which are aimed at the avoidance of temperature gradients in the balance structure. O.C.

**A86-25197#**

**A WORLD REVIEW ON AIR BREATHING ENGINE ALTITUDE TEST FACILITIES**

Y. MIURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 376, 1985, p. 251-266. In Japanese. refs

The current status and future prospects of the air breathing engine altitude test facilities are reviewed with an emphasis on the test cell main body. The principle of the air breathing engine altitude test and its methods including the direct connect and free jet methods are characterized. The testing facilities of the air breathing engine altitude in the U.S.A., England, and France are compared. S.H.

**A86-26029**

**THE DEVELOPMENT OF AN ADVANCED HELICOPTER RESEARCH SIMULATOR**

F. J. MALKIN (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 213-216.
(SAE PAPER 841610)

The development of a research simulator for an advanced helicopter cockpit is described. The purpose of the simulator is to evaluate the impact on human performance of multifunctional controls and displays, to be implemented in a family of light military helicopters. The objectives of the research is to tailor the crew station by reducing control and display interaction required of the operators, and by maximizing information transfer. The control input devices to be evaluated include key pads, touch-sensitive screens, joy sticks, and voice-actuated controls. In addition, various display formats, the optimum number of displays required, their arrangement and location, the helmet-mounted and panel-mounted displays, speech input/output applications, manual versus automated control tradeoffs, and side-arm control considerations will be investigated. The configuration of the simulator, the crew station, and the experimenter's console are described. I.S.

**A86-26148#**

**DFVLR HELICOPTER IN-FLIGHT SIMULATOR FOR FLYING QUALITY RESEARCH**

B. GMELIN, G. BOUWER, and D. HUMMES (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 20 p. refs

New missions for civil and military helicopters lead to increasing higher demands in the field of flying qualities. The necessary research activities require extensive ground-based simulations and flight tests in particular. For flight testing, operational helicopters and research helicopters with variable dynamic characteristics are used for specific tasks. In order to fulfill the research needs for future helicopter systems, in-flight simulators will play an important role in flying quality research. The intention of this paper is to discuss the need for and the tasks of an in-flight simulator for flying quality research with emphasis on DFVLR activities. The DFVLR in-flight simulator BO 105 ATTHeS is described including the model following control system design and realization. First results of a ground-based simulation program and flight tests are presented showing the efficiency of the concept and demonstrating the potential for future flying quality research. Author

**A86-26149*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AIRCREW-AIRCRAFT INTEGRATION - A SUMMARY OF U.S. ARMY RESEARCH PROGRAMS AND PLANS**

D. L. KEY and E. W. AIKEN (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 22 p. Previously announced in STAR as N85-11004. refs

A review of selected programs which illustrate the research efforts of the U.S. Army Aeromechanics Laboratory in the area of aircrew-aircraft integration is presented. Plans for research programs to support the development of future military rotorcraft are also described. The crew of a combat helicopter must, in general, perform two major functions during the conduct of a particular mission: flightpath control and mission management. Accordingly, the research programs described are being conducted in the same two major categories: (1) flightpath control, which encompasses the areas of handling qualities, stability and control, and displays for the pilot's control of the rotorcraft's flightpath, and (2) mission management, which includes human factors and cockpit integration research topics related to performance of navigation, communication, and aircraft systems management tasks. Author

**A86-26152#**

**WIDE-ANGLE, LOW-ALTITUDE FLIGHT SIMULATOR VISION SYSTEM FOR COCKPIT RESEARCH AND AIRCREW TRAINING**

A. CORT and R. HAWTIN (Westland Helicopters, Ltd., Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 13 p.

A low cost helicopter flight simulator capable of reproducing night vision goggle flight over a height range of 0 to 300 ft and with a lateral field-of-view of 270 degrees has been developed by the Westland vision system (Vistasim). A terrain image stored in a photographic transparency that is projected onto a spherical screen surrounding the simulator cockpit by the point source projection technique is used and a sharp, bright image is achieved using a low power monochromatic laser. A servomechanism producing 6 degrees of freedom of movement of the transparency with respect to the projection screen generates the illusion of movement. A computerized mathematical flight model of the aircraft provides the necessary interface between the pilot's controls and the servomechanism. Despite tradeoffs made between allowable rotation angles, transparency size, dome size, light power and image distortion, the system exceeds all but the most advanced CGIs in scene content and realism. R.R.

**N86-18328*#** National Aeronautics and Space Administration, Washington, D.C.

**AERONAUTICAL FACILITIES CATALOGUE. VOLUME 2: AIRBREATHING PROPULSION AND FLIGHT SIMULATORS**

F. E. PENARANDA and M. S. FREDA Dec. 1985 242 p 2 Vol.

(NASA-RP-1133; NAS 1.61:1133) Avail: NTIS HC A11/MF A01 CSCL 14B

Volume two of the facilities catalogue deals with Airbreathing Propulsion and Flight Simulation Facilities. Data pertinent to managers and engineers are presented. Each facility is described on a data sheet that shows the facility's technical parameters on a chart and more detailed information in narratives. Facilities judged comparable in testing capability are noted and grouped together. Several comprehensive cross-indexes and charts are included. Author

**N86-18329*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**CURRENT WIND TUNNEL CAPABILITY AND PLANNED IMPROVEMENTS AT LEWIS RESEARCH CENTER**

D. N. BOWDITCH 1986 24 p refs Prepared for presentation at the 14th Aerodynamic Testing Conference, West Palm Beach, Fla., 5-7 Mar. 1986; sponsored by AIAA

(NASA-TM-87190; E-2844; NAS 1.15:87190) Avail: NTIS HC A02/MF A01 CSCL 14B

As the propulsion and power generation center of NASA, Lewis has designed its wind tunnels for propulsion research. Therefore, the 8 by 6 Foot Supersonic Wind Tunnel and the 10 by 10 Foot Supersonic Wind Tunnel provide the capability to test operating propulsion systems from Mach 0.4 to 3.5. The 9 by 15 Foot Wind Tunnel can investigate propulsion installation problems at the lower takeoff and landing speeds and provides an excellent anechoic environment to measure propeller and fan noise. The Lewis Central Air System provides steady air supplies to 450 psi, and exhaust to 3 in. of mercury absolute, which are available to the wind tunnels for simulation of jets and engine induced flows. The Lewis Icing Research Tunnel is the largest in the free world that can produce icing conditions throughout the year. Rehabilitation of the Altitude Wind Tunnel at Lewis would allow testing of propulsion systems in the upper left hand corner which would be a unique capability. Also, in a mothballed state at Lewis, the Hypersonic Tunnel Facility could provide the best simulation of nonvitiated Mach 5-7 test conditions available. Studies are currently being made of the Lewis facilities to identify enhancements of their research potential for the 1990's and beyond. Author

**N86-18333#** Air Force Human Resources Lab., Brooks AFB, Tex.

**FLIGHT TRAINING SIMULATORS. EFFECTS OF TERRAIN ACCURACY ON SIMULATED RADAR IMAGE QUALITY Interim Technical Paper, Sep. 1984 - May 1985**

P. M. CRANE Sep. 1985 18 p

(Contract AF PROJ. 614)

(AD-A160905; AFHRL-TP-85-28) Avail: NTIS HC A02/MF A01 CSCL 17I

This experiment evaluated the effect of terrain vertical accuracy on the quality and perceived training effectiveness of simulated radar images. Seven Air Force navigators judged the quality and training value of digital radar landmass imagery produced at six different levels of terrain vertical accuracy. Each image represented the simulated ground mapping radar image of a mountainous area viewed from an altitude of 10,000 feet. The results indicated that: (1) increasing terrain vertical accuracy above the current production standard did not significantly increase either the judged quality of the imagery or its perceived training value; and (2) decreasing terrain vertical accuracy below the current production standard significantly increased either the judged quality of the imagery or the perceived training value of the imagery. Although the results of this experiment do not provide any justification for more stringent accuracy requirements, it is recommended that this experiment be replicated using lower altitude imagery in which the effects of terrain evaluation are more pronounced. GRA

**N86-19330*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE ROLE OF A REAL-TIME FLIGHT SUPPORT FACILITY IN FLIGHT RESEARCH PROGRAMS**

A. L. MOORE Jan. 1986 14 p refs Presented at the AIAA Aerospace Sciences Meeting, Reno, Nev., 6-9 Jan. 1986

(NASA-TM-86805; H-1335; AIAA-86-0166; NAS 1.15:86805)

Avail: NTIS HC A02/MF A01 CSCL 14B

This paper presents some of the approaches taken by the NASA Western Aeronautical Test Range (WATR) of Ames Research Center to satisfy the ever-increasing real-time requirements of research projects such as the F-14, F-15, advanced fighter technology integration (AFTI) F-16, YAV-8B, and the X-29A. The approaches include the areas of data acquisition, communications (video and audio), real-time processing and display, data communications, and tracking. Author

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## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-24841**

**DEVELOPMENT OF AUTONOMOUS POWER SYSTEM TESTBED**

J. R. BARTON, M. E. LIFFRING (Boeing Aerospace Co., Seattle, WA), and T. ADAMS (Advanced Information and Decision Systems, Mountain View, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.466-1.471.

A power system testbed has been assembled to advance the development of large autonomous electrical power systems required for the space station, spacecraft, and aircraft. The power system for this effort was designed to simulate singleor dual-bus autonomous power systems, or autonomous systems that reconfigure from a single bus to a dual bus following a severe fault. The approach taken was to provide a flexible power system design with two computer systems for control and management. One computer operates as the control system and performs basic control functions, data and command processing, charge control, and provides status to the second computer. The second computer contains expert system software for mission planning, load management, fault identification and recovery, and sends load and configuration commands to the control system. Author

**N86-20196#** Joint Publications Research Service, Arlington, Va.
**ANALYTICAL EVALUATIONS OF ACCURACY IN DETERMINING AND PREDICTING PARAMETERS OF ARTIFICIAL EARTH SATELLITE MOTION USING ALTIMETER MEASUREMENT DATA Abstract Only**
M. P. NEVOLKO and Y. L. MOSIN *In its* USSR Report: Space (JPRS-USP-86-001) p 91 13 Jan. 1986 Transl. into ENGLISH from Kosmicheskiye Issledovaniya (Moscow, USSR), v. 23, no. 2, Mar. - Apr. 1985 p 310-314 Original language document was announced in IAA as A85-35246
Avail: NTIS HC A03

The proposed analytical estimation procedure is based on the methods of Porfir'ev and Smirnov (1968) and Bychkov and Boginskii (1972). It is shown that the main contribution to the prediction error according to the radius vector as well as along the orbit is from variations of atmospheric density. B.J. (IAA)

## 11

## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-23274**
**GAS TURBINE FUELS AND THEIR INFLUENCE ON COMBUSTION**
J. ODGERS and D. KRETSCHMER (Universite Laval, Quebec, Canada) Tunbridge Wells, England, Abacus Press (Energy and Engineering Science Series. Volume 5), 1986. 195 p. refs

The range of possible fuels from solids through liquids to gases is examined, and their possible applications to gas turbines of all types are considered. The influence of fuel properties on combustion performance is examined with the objective of providing information which will help in the design of a satisfactory combustion system. Anticipated fuels are considered, using measured data from existing fuels which bracket the forecast properties of the future fuels. C.D.

**A86-23450**
**DETERMINATION OF THE SERVICE LIFE OF AVIATION OILS [OPREDELENIE SROKOV SLUZHBY AVIATSIONNYKH MASEL]**
V. G. KUZNETSOV, G. T. NOVOSARTOV, A. I. ECHIN, and V. N. BAKUNIN Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 11, 1985, p. 39, 40. In Russian.

A procedure for determining the actual service life of the oils used in gas-turbine aircraft engines is proposed which is based on an experimental evaluation of the thermal oxidation stability of the oils using laboratory testing equipment. In particular, the method involves a study of the dynamics of changes in the contents of the principal additives and in the indices characterizing the service properties of the oil. Measurements of the additive contents and quality indices are made at certain intervals of time during the oxidation of oil in the laboratory. Each of the values is plotted against the time of oxidation, and the contents of additives an abrupt degradation of the oil properties are determined. This minimum additive content is then used as an oil performance criterion which determines the maximum allowable service life. Test results are presented for B-3V and IMP-10 aviation oils. V.L.

**A86-23690**
**CURRENT CONCEPTS OF COMPOSITE APPLICATIONS IN AIRCRAFT AND ENGINES [SOVREMENNYE KONTSEPTSII PRIMENENIIA KOMPOZITNYKH MATERIALOV V LETATEL'NYKH APPARATAKH I DVIGATELIAKH]**
A. S. VOLMIR Mekhanika Kompozitnykh Materialov (ISSN 0203-1272), Nov.-Dec. 1985, p. 1049-1056. In Russian. refs

Current applications of composite materials in aircraft structures and engines are briefly reviewed, with attention given to fiber-glass plastics, organic-fiber plastics, boron/aluminum, carbon composites, hybrid carbon/Kevlar composites, and other advanced composite materials. The performance characteristics of various composites are examined and compared with those of the traditional aircraft materials. The problems arising in the design, manufacture, and operation of aircraft, engines, and their components in the case of the partial or complete substitution of composite materials for the traditional structural materials are discussed. V.L.

**A86-23823**
**FIBER-REINFORCED PLASTIC COMPOSITES FOR ENERGY ABSORPTION PURPOSES**
P. H. THORNTON, J. J. HARWOOD, and P. BEARDMORE (Ford Motor Co., Dearborn, MI) (International Symposium on Composites: Materials and Engineering, University of Delaware, Newark, Sept. 24-28, 1984) Composites Science and Technology (ISSN 0266-3538), vol. 24, no. 4, 1985, p. 275-298. refs

The energy-absorbing characteristics in axial collapse of structures made from fiber-reinforced plastic (FRP) composites are reviewed from both the materials and the structural viewpoints. The type and nature of the fiber and resin, the geometry of the structure and the fiber arrangement affect significantly the energy-absorbing capability, but the data currently available are not yet sufficient to give a clearly unambiguous answer for a particular situation. An effective trigger mechanism is necessary to initiate stable collapse since thin-wall structures in particular are prone to unstable collapse. Methods are described to estimate the energy-absorbing potential of an FRP composite tructure. Author

**A86-23868#**
**THE PRODUCTION OF JET FUEL FROM ALTERNATE SOURCES**
H. R. LANDER, JR. (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) and H. E. REIF (Sun Refining and Marketing Co., Marcus Hook, PA) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p. refs
(ASME PAPER 85-IGT-67)

The most significant potential source of aviation gas turbine fuels in the continental United States of America is the western oil shale located in the Rocky Mountain States of Colorado, Utah, and Wyoming. Nearly 600 billion barrels of recoverable oil is located in this area. This paper discusses the availability of oil shale and reviews the recovery, upgrading and refining schemes necessary to produce fuel which can be used in present-day aircraft. Other synthetic fuels are discussed with regard to the processing necessary to produce suitable fuels for today's high performance aircraft. Heavy oil and tar sand bitumen are likely to be refined in the next decade. Methods for producing suitable fuels are discussed. The chemical structure of these sources, whigh is basically cyclic, leads to the potential of heavier fuels with more energy per given volume and therefore longer range for certain aircraft. This exciting possibility is reviewed. Author

**A86-23911#**

### TEST AND EVALUATION OF SHALE DERIVED JET FUEL BY THE UNITED STATES AIR FORCE

C. L. DELANEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p. refs
(ASME PAPER 85-IGT-115)

An evaluation is made of the results obtained to date by the U.S. Air Force's shale-derived synthetic gas turbine engine fuel test program, with attention to the quality assurance measures being implemented to ensure that these fuels meet the JP-4 fuel standard defined by MIL-T-5624L. Compatibility has been established for the synthetic fuel with all materials currently used in aircraft fuel systems, storage facilities, and ground support equipment. A lubricity additive is, however, noted to be required for operation with the F100 engine of the F-15 and F-16 fighters. O.C.

**A86-23922*#** United Technologies Research Center, East Hartford, Conn.

### FUEL DEPOSIT CHARACTERISTICS AT LOW VELOCITY

E. J. SZETELA, A. J. GIOVANETTI (United Technologies Research Center, East Hartford, CT), and S. COHEN (NASA, Lewis Research Center, Cleveland, OH) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(Contract NAS3-24091)
(ASME PAPER 85-IGT-130)

An experimental characterization has been made of the relationship between deposit mass, operating time, and temperature in studies of aviation gas turbine fuel thermal stability, in order to support fuel system designs that are more efficient through deposit buildup prevention. A novel thermal stability test apparatus has been developed for the determination of deposition rates over a range of temperatures, in tests of up to several hundred hours duration. In the case of heated stainless steel tubes at low velocity with Jet A fuel, the deposits obtained were thick, porous, and nonuniform. O.C.

**A86-24636#**

### A NUMERICAL ANALYSIS OF SINGULAR STRESS FIELDS AT THE FREE EDGE OF LAYERED COMPOSITES

L. ANQUEZ (ONERA, Chatillon-sous-Bagneux, France) (European Mechanics Colloquia, Colloquium on Structure and Crack Propagation in Brittle Matrix - Composite Materials, 204th, Jablonna, Poland, Nov. 12-15, 1985) ONERA, TP, no. 1985-154, 1985, 16 p. refs
(ONERA, TP NO. 1985-154)

The stresses near a straight, free edge in (+alpha, -alpha) sub s composite laminates subjected to uniform axial strain are studied using a pseudo-three-dimensional finite element analysis. Based on the numerical analysis, expressions for the components of the stress tensor near the intersection of the interface and free edge are presented. The results indicate that, for the type of problem analyzed here, a singularity exists which is of the logarithmic, and not the power, type. C.D.

**A86-24986*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### INTERLAMINAR FRACTURE OF COMPOSITES

T. K. OBRIEN (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 37, Feb. 1985, p. 61-69. Previously announced in STAR as N84-27835. refs

Fracture mechanics has been found to be a useful tool for understanding composite delamination. Analyses for calculating strain energy release rates associated with delamination growth have been developed. These analyses successfully characterized delamination onset and growth for particular sources of delamination. Low velocity impact has been found to be the most severe source of composite delamination. A variety of test methods for measuring interlaminar fracture toughness are being developed to identify new composite materials with enhanced delamination resistance. Author

**A86-26158#**

### ARALL - A LIGHT WEIGHT STRUCTURAL MATERIAL FOR IMPACT AND FATIGUE SENSITIVE STRUCTURES

J. W. GUNNINK, M. L. C. E. VERBRUGGEN, and L. B. VOGELESANG (Delft, Technische Hogeschool, Netherlands) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 16 p. refs

A new hybrid material is obtained by incorporating 'high modulus' fibers into the bondline of laminated sheet material. This material is called ARALL (Aramid Reinforced Aluminium Laminate). Principally ARALL was developed to obtain a material with very good fatigue properties, in which possible cracks would grow very slowly. However, it turns out that ARALL is also a strong material with relatively low density. Preliminary tests have shown that the material also has promising impact and energy absorbing properties, which may qualify it as an interesting material for those applications where a high degree of ballistic tolerance is required. Aircraft design studies have indicated that, especially for fatigue sensitive areas such as the lower wing and the skin of a pressure cabin, ARALL is an attractive material. Weight savings of more than 30 percent should be attainable in practice. This paper gives a survey of the ARALL production process, and the properties of the material including mechanical properties, durability and some workshop aspects. Properties of joints and some applications of the material are also discussed. Author

**A86-26159#**

### CORROSION PROTECTION OF HELICOPTERS THROUGH ORGANIC COATINGS

H. S. M. BALVERS (Sikkens Aerospace Finishes, Sassenheim, Netherlands) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 9 p.

For decades, aluminum-based alloys have been the most important construction material in the helicopter industry and in the aircraft industry in general. The reason for this situation is related to the favorable 'mechanical strength-weight' ratio provided by aluminum materials. However, a disadvantage of suitable aluminum alloys is a limited resistance against corrosion. The present paper provides a description of various materials which can be used as protective coatings for aluminum alloys, taking into account inorganic and organic coatings. After an evaluation of the various approaches avaiable to protect an aluminum alloy with the aid of a coating, it is concluded that organic coatings are indispensable to obtain the best possible protection for aircraft in general and helicopters in particular. G.R.

**N86-18441*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### FIRE-RETARDANT DECORATIVE INKS FOR AIRCRAFT INTERIORS

D. A. KOURTIDES, Z. NIR (Makhteshim, Ltd., Beersheeba, Israel), and J. A. MIKROYANNIDIS (Patras Univ., Greece) Dec. 1985 14 p refs
(NASA-TM-88198; A-85414; NAS 1.15:88198) Avail: NTIS HC A02/MF A01 CSCL 07C

Commercial and experimental fire retardants were screened as potential fire retardants for acrylic printing inks used on aircraft interior sandwich panels. The fire retardants are selected according to their physical properties and their thermostabilities. A criterion for selecting a more stable fire retardant is established. Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) are used to determine thermostabilities. Results show that the fire retardant formulations are more thermally stable than the acrylic ink control. It is determined that an ink formulation containing a brominated phenol and carboxy-terminated butadiene acrylonitrile which has been modified with a brominated polymeric additive (BPA), yields the highest limiting oxygen index (LOI) of all the compounds tested. All of the fire-retardant formulations have a higher oxygen index than the baseline acrylic ink. Author

**N86-18448*#** Boeing Commercial Airplane Co., Seattle, Wash.
**THE 737 GRAPHITE COMPOSITE FLIGHT SPOILER FLIGHT SERVICE EVALUATION Report, May 1981 - Dec. 1984**
R. L. COGGESHALL Jul. 1985 84 p refs
(Contract NAS1-11668)
(NASA-CR-172600; NAS 1.26:172600; D6-53021; REPT-8) Avail: NTIS HC A05/MF A01 CSCL 11D

The flight service experience of 111 graphite-epoxy spoilers on 737 transport aircraft and related ground based environmental exposure of graphite-epoxy material specimens is covered. Spoilers have been installed on 28 aircraft representing seven major airlines operating throughout the world. An extended flight service evaluation program of 15 years is presently underway. As of December 1984, a total of 2,092, 155 spoiler flight hours and 2,954,814 spoiler landings had been accumulated by this fleet. Author

**N86-18449*#** Boeing Commercial Airplane Co., Seattle, Wash.
**ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL AIRCRAFT Report, Apr. 1982 - Mar. 1985**
R. L. COGGESHALL Nov. 1985 82 p refs
(Contract NAS1-15148)
(NASA-CR-177929; NAS 1.26:177929; D6-53020) Avail: NTIS HC A05/MF A01 CSCL 11D

The effects of environmental exposure on composite materials are determined. The environments considered are representative of those experienced by commercial jet aircraft. Initial results have been compiled for the following material systems: T300/5208, T300/5209, and T300/934. Future results will include AS-1/3501-6 and Kevlar 49/F161-188. Specimens are exposed on the exterior and interior of 737 airplanes of three airlines, and to continuous ground-level exposure at four locations. In addition, specimens are exposed in the laboratory to conditions such as: simulated ground-air-ground, weatherometer, and moisture. Residual strength results are presented for specimens exposed for up to five years at five ground-level exposure locations and on airplanes from one airline. Author

**N86-18451#** Drexel Univ., Philadelphia, Pa. Ultrasonics Research Lab.
**ULTRASONIC F-SCAN INSPECTION OF COMPOSITE MATERIALS Final Report, 9 May 1983 - 9 May 1984**
J. L. ROSE, J. B. NESTLEROTH, and K. SUBRAMANIAN 13 Sep. 1985 102 p Original contains color illustrations
(Contract N68335-83-C-0739; F41-461)
(AD-A159974; NAEC-92-190) Avail: NTIS HC A06/MF A01 CSCL 17A

Composites are being used in high-strength, low-weight applications such as the aircraft industry. Difficulties arise in the nondestructive testing and evaluation of these materials because of their fibrous nature. Therefore, a study was connected to evaluate, improve, and optimize ultrasonic techniques for the detection of programmed delaminations and other defects in graphite/epoxy composite laminates. A pulse echo testing mode was used and C-scan results were analyzed. To overcome the limits of traditional C-scan, F-scanning (Feature scanning) was also used. This method examines many characteristic features of the ultrasonic waveform such as amplitude, frequency shifts, etc. Feature scanning has the potential to precisely locate and characterize the defects. Micrographic analyses were made to determine defective and good areas for correlation with the results obtain in the F-scan process. The results of the C-scan, F-scan, and photomicrographs showed an excellent correlation. Specific conclusions are drawn to assist future operators in conducting consistent and reliable C-scans. Situations where F-scanning might be suitable are also reviewed. Author (GRA)

**N86-19447#** Joint Publications Research Service, Arlington, Va.
**POWDERED, SINTERED ALLOY MATERIALS DESCRIBED: DEVELOPMENT OF TITANIUM ALLOYS**
M. YAMAZAKI and H. ONODERA *In its* Japan Report: Science and Technology (JPRS-JST-86-003) p 1-12 11 Feb. 1986 refs Transl. into ENGLISH from Kogyo Zairyo (Tokyo, Japan), v. 32, no. 13, Dec. 1984 p 25-31
Avail: NTIS HC A05/MF A01

As part of a system for the next generation, in parallel with the development of titanium alloys to meet the target performance of strength relative to high temperature (tensile strength/specific gravity), ductility and superplasticity properties, technological advances are studied for the manufacture of products such as compressor rotors with high yield, using superplasticity processing through powder metallurgy techniques. Techniques of alloy development as well as development status are explained, together with an outline of production techniques for components being studied at the Central Research Institute of Mitsubishi Metal Corporation. Author

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# ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-22716**
**MAGNETIC TAPE RECORDING UNDER SEVERE ENVIRONMENTAL CONDITIONS [MAGNETBANDAUFZEICHNUNG UNTER ERSCHWERTEN UMVELTBEDINGUNGEN]**
K. GROBBINK (Sangamo Electric GmbH, Essen, West Germany) IN: European Telemetry Conference, 7th, Boeblingen, West Germany, May 21-24, 1984, Reports. Part 1 . Wessling, West Germany, Arbeitskreis Telemetrie, 1984, p. 2.2-2.2.12. In German. refs

The design of magnetic tape recorders intended forse under severe environmental conditions is discussed. The requirements that must be met by such instruments and the particular stresses to which they are subject in use are examined. The components of a modern airborne tape recorder are described, including the tape drive, heads, current supply, power amplifier, and replay technology. C.D.

**A86-23001**
**INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, 31ST, LAS VEGAS, NV, APRIL 30-MAY 2, 1985, PROCEEDINGS**
Mount Prospect, IL, Institute of Environmental Sciences, 1985, 579 p. For individual items see A86-23002 to A86-23026.

Among the topics discussed are: clean room particle instrumentation; screening procedures and materials testing for space applications; and vacuum bakeout conditioning for molecular contamination control. Consideration is also given to: sources and measurements of surface contamination; contamination control in the fabrication of optical devices; garments and wipers; and electrostatics control. Additional topics include: particle identification in liquids and gases; particulates in gases; and contamination in liquids. I.H.

**A86-23003**

**AVIP AIR FORCE THRUST FOR RELIABILITY**

J. C. HALPIN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Institute of Environmental Sciences, Annual Technical Meeting, 31st, Las Vegas, NV, April 30-May 2, 1985, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1985, p. 206-218.

Methods for ensuring reliability of electronics components (Avionics Integrity Programs or AVIPs) on board military aircraft are discussed. The general principles incorporated into environmental stress screening programs for electronics applications are described in detail. Among the screening programs considered are: burn-in stress screening simulating realistic aircraft stresses, and enhanced environmental stress screening to detect components having the worst flaws. A testing approach for characterizing fatigue failures in printed wiring boards is illustrated in a block diagram. I.H.

**A86-23011**

**EVOLUTION OF EMERGING ENVIRONMENTAL TESTING AND EVALUATION TECHNIQUES**

A. H. BURKHARD (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Institute of Environmental Sciences, Annual Technical Meeting, 31st, Las Vegas, NV, April 30-May 2, 1985, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1985, p. 302-309. refs

The contemporary statistically based environmental test and evaluation techniques used to develop and qualify electronic systems will be too costly and time consuming for emerging equipment systems with much higher levels of reliability than current systems. The current emphasis on physical testing needs to be reduced and blended with the emerging analytical computerized tools to develop a more cost effective approach to evaluate the environmental suitability of electronic systems. It is proposed that an integrated approach based upon fracture mechanics concepts of latent defects growth and/or a nondestructive inspection techniques could yield such an approach. Author

**A86-23015**

**UNSCREENED PART RELIABILITY RIVALS THAT OF SCREENED PARTS IN NEW DIGITAL AVIONICS**

T. R. BRENNOM (Rockwell International Corp., Collins Avionics Div., Cedar Rapids, IA) IN: Institute of Environmental Sciences, Annual Technical Meeting, 31st, Las Vegas, NV, April 30-May 2, 1985, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1985, p. 332-336.

Early field operational data of Collins products on new Boeing 767 and 757 aircraft has shown stadard, full temperature range electrical parts have similar reliability levels as high reliability/screened electrical parts. This study is considered to be unique in that the only significant variable was part screening. Historical background into the use of failure rate sources at the Collins Avionics Divisions including some early screened part reliability results are included. Comparisons are made of actual and predicted field reliability levels of piece part failure rate data from early operation of the new Collins 700 Series Digital Products. A brief description of future needs in this area is also presented. Author

**A86-23253**

**AIRBORNE INSTRUMENTATION MAGNETIC TAPE RECORDING THRU THE EARLY 90'S**

W. D. WESSLER (Fairchild Weston Systems, Inc., Sarasota, FL) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 1-1 to 1-5.

Today's state-of-the-art airborne instrumentation tape recording is reviewed as background. Advantages and limitations of magnetic tape, as compared to other storage medium are considered, then practical present day longitudinal and helical recording is discussed. Following this a recorder manufacturer's projection of what the Flight Test Engineer can expect thru the early 1990's is presented. Bit rate, error rates, areal and volumetric packing densities as well as recorder weights and dimensions are considered. Author

**A86-23256**

**USE OF VIDEO CASSETTE RECORDERS FOR COMBINED VIDEO AND PCM DATA RECORDING**

R. J. MCQUILLAN (USAF, Flight Test Center, Edwards AFB, CA) and L. GALLO (Merlin Engineering Works, Palo Alto, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 5-1 to 5-5.

Analog tape recorders are commonly used in aircraft flight testing to record PCM digital data. These recorders require considerable space and add significantly to the cost of test instrumentation. For limited test programs in densely packed aircraft, such as the modern fighter, the burden of a conventional reel to reel analog recorder is oppressive. With this condition in mind, the desirability of recording PCM data on a video cassette recorder surfaced. The video cassette recorder (VCR) offers greatly improved size and cost efficiency over conventional reel to reel recorders for many data acquisition requirements. Not only are cost and size improved, but several other benefits are realized. For instance, video cassettes are easily stored and transported. Automatic synchronization of the digital data and video images is inherent in the combined recording system. The system described in this paper makes use of a small electronic interface unit to combine and synchronize the video and PCM data signals. This composite signal is then recorded on a standard VHS video recorder. PCM data rates of up to thirty kilobits per second can be accomodated with only a minor reduction of picture area. Author

**A86-23262**

**FURTHER DEVELOPMENT IN STORES SEPARATION DATA ACQUISITION AND REDUCTION**

R. A. HERBERT (Aerospace Engineering Test Establishment, Medley, Canada) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 11-1 to 11-5.

The Canadian Forces flight test agency, Aerospace Engineering Test Establishment (AETE) was required to conduct a weapons clearance program on their CF18 aircraft in a very compressed time frame. One of the most time consuming of the activities was that of obtaining store separation in six degrees of freedom (6 DOF) using a single camera, photometrics technique. This paper describes some of the hardware and software improvements made to increase data throughput rates, improve data integrity and presentation, and data accuracy where possible. Author

**A86-23266**

**A NEW HIGH TEMPERATURE SILICON ON SAPPHIRE TRANSDUCER FOR JET ENGINE CONTROL APPLICATIONS**

A. J. PETERS (Bourns Instruments, Inc., Riverside, CA) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 15-1 to 15-4.

A new pressure transducer has been designed using silicon on sapphire technology. This transducer has been primarily designed for use in jet aircraft monitoring and control applications. The heart of this device is a single crystal sapphire substrate with epitaxially deposited silicon strain gages in intimate contact with the sapphire. The sapphire substrate becomes the pressure sensitive diaphragm and the strain gage resistance change is directly proportional to applied pressure. The transducer exhibits excellent linearity and low hysteresis due to the crystalline nature of the diaphragm. The transducer is fabricated using materials that have excellent thermal expansion match properties and is capable of operating at temperatures up to 500 degrees Fahrenheit. A means of monitoring diaphragm temperature is also included in the design. This paper contains a complete description of the fabrication process and the performance characteristics of this new device. Author

**A86-23281**

### AIR FLOW AND PARTICLE TRAJECTORIES AROUND AIRCRAFT FUSELAGES. III - EXTENSIONS TO PARTICLES OF ARBITRARY SHAPE

W. D. KING (National Center for Atmospheric Research, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 2, Dec. 1985, p. 539-547. refs

Earlier work that produced generalized rules for obtaining trajectories of water droplets moving around aircraft fuselages has been extended to cover the case for particles of arbitrary shape. The parameters determining the major features of the trajectories are the fuselage radius and a generalized Stokes number that can be used to calculate an equivalent water drop size for particles of arbitrary shape and density. As for water drops, the maximum width of the shadow zone for sampling the particles is about one-fifth of the fuselage radius, and it occurs for those ice columns and plates of typical densities whose major dimensions are about 600 microns and 2 mm, respectively. Author

**A86-23403**

### PREDICTION AND MEASUREMENT OF NEAR FIELDS FOR ANTENNAS ON STRUCTURES

L. C. CALMON (University College, London, England) and M. S. SMITH (Standard Telecommunication Laboratories, Ltd., Harlow, England) Institution of Electronic and Radio Engineers, Journal (ISSN 0267-1689), vol. 55, Nov.-Dec. 1985, p. 407-414. refs

Techniques for predicting near fields of antennas on limited ground planes, aircraft and other vehicles, have been developed. Wire grid modelling is used to calculate the current distribution over the metal structure, from which the fields close to the surface can be found. These field values could then be used in a quasi-static analysis to predict aperture penetration fields, with application to electromagnetic compatibility. A new form of electric field probe with an optical fibre link has been developed, which has been used to obtain experimental measurements to compare with the theoretical predictions. The agreement obtained is very close, confirming the theory and showing that the probe gives unperturbed and accurate measurements. Author

**A86-23651**

### THE PROBLEM OF OPTIMIZING THE FINAL DESIGN MODIFICATIONS OF STOCHASTIC OSCILLATORY SYSTEMS [K ZADACHE OPTIMAL'NOI 'DORABOTKI' SLUCHAINYKH KOLEBATEL'NYKH SISTEM]

S. V. ARINCHEV and V. V. BYSTROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 3-7. In Russian. refs

The problem of optimizing the final design modifications of flight vehicle structures is formulated in mathematical terms with allowance for random factors. The optimization problem consists in ensuring a specified degree of system reliability with minimum design changes. An algorithm for solving the problem is proposed, and an example is included. V.L.

**A86-23653**

### CALCULATION OF THE HEATING OF A LIQUID COMPONENT PARTIALLY FILLING A CONTAINER [RASCHET PROGREVA ZHIDKOGO KOMPONENTA, CHASTICHNO ZAPOLNIAIUSHCHEGO REZERVUAR]

N. L. BACHEV and A. A. KOZLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 13-17. In Russian.

The convective flux toward the free surface of the fuel tanks of aircraft on the ground or in flight produces convective flows in the liquid fuel and leads to the stratification of the liquid. Here, the flows of this kind are analyzed by solving numerically nonstationary equations of thermal convection without any assumptions concerning the flow structure. By using this approach, the heating of the liquid is determined for Re up to 7 x 10 to the 11th. V.L.

**A86-23652**

### A THEORY OF LARGE AND FINITE DISPLACEMENTS OF BARS [TEORIIA BOL'SHIKH I KONECHNYKH PEREMESHCHENII STERZHNEI]

V. A. PAVLOV, S. A. MIKHAILOV, and V. G. GAINUTDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 55-58. In Russian. refs

A theory for analyzing systems of bars under conditions of large displacements is presented which makes it possible to analyze the stress-strain state of a structure as a function of its deformability. In passing to the limit, the theory developed here is shown to yield Prandtl-Timoshenko equations. V.L.

**A86-23663**

### SURFACES ON A NONRECTANGULAR FRAME [POVERKHNOSTI NA NEPRIAMOUGOL'NOM KARKASE]

A. D. TUZOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 66-70. In Russian.

A method is presented for constructing a surface over a frame consisting of a set of nonrectangular areas whose opposite boundaries are of different parametric length. Equations for the portions of the surface are obtained by using the Boolean sum and tensor product methods. The equations presented here yield, as a particular case, a well-known equation for a rectangular region. V.L.

**A86-23666**

### A QUICK METHOD FOR ESTIMATING HEAT TRANSFER TO A COOLANT [EKSPRESS-METOD OTSENKI TEPLOOTDACHI V OKHLADITEL']

A. B. SHIGAPOV and E. A. DAUTOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 79-84. In Russian. refs

A special nomogram and graphs are presented which provide a convenient way to calculate heat transfer to the coolant in ducts with a developed heat transfer surface, such as the cooling channels of aircraft engines. The method proposed here makes it possible to significantly reduce the time and effort required for calculating flow-type engine cooling systems. The method can be used for approximate estimates at the stage of preliminary design. V.L.

**A86-23755**

### IN SITU METHODS FOR CRACK DETECTION IN THE MASTER CONNECTING RODS OF M 462 RF AIRCRAFT ENGINES [BEZDEMONTAZNI METODY ZJISTOVANI TRHLIN V HLAVNICH OJNICICH LETECKYCH MOTORU M-462 RF]

R. SYKORA Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 165-171. In Czech.

The following methods are examined to determine their suitability for in situ crack detection in the master connecting rods of aircraft engines: (1) analysis of the vibration spectra from the cylinder containing the master connecting rod during engine operation; (2) analysis of the noise spectra and their changes with time during engine operation; and (3) analysis of the spectra of acoustic signals generated by impacts on the master connecting rod. Recorded spectra and frequencies characterizing cracks in the master connecting rods are presented. It is shown that each of the methods studied is capable of detecting cracks in master connecting rods. V.L.

**A86-23759**

### USING WEAR PRODUCTS FOR ASSESSING AND PREDICTING THE CONDITION OF AIRCRAFT JET ENGINES [VYUZITI PRODUKTU OPOTREBENI K HODNOCENI A PROGNOZOVANI STAVU LETECKYCH PROUDOVYCH MOTORU]

L. SOTEK Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1985, p. 195-198. In Czech. refs

The principal problems associated with friction and wear in gas-turbine aircraft engines are examined, and the possibility of using certain tribological techniques for evaluating and predicting the condition of the engines is discussed. The possibilities afforded by such methods are demonstrated with reference to test results for two jet engines of the same type. V.L.

**A86-23873#**

**THE FINITE ELEMENT STRESS ANALYSIS FOR SOLID-SHELL COMBINED PARTS IN AEROENGINES**

Z. YIN, P. REN, and J. YIN (Nanhua Powerplant Research Institute, Zhuzhou, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 8 p. refs
(ASME PAPER 85-IGT-72)

In the finite element stress analysis of solid-shell combined parts in aeroengines, isoparametric solid elements, superperametric shell elements, solid-shell transition elements, and a series of coarse-fine mesh transition elements have been specially established and used so that the parts of complex shape can be modeled realistically and the amount of input data and computing time can be reduced. In this paper, the basic method used, the formulation of the various elements, and solutions to the equilibrium equations are presented, and the function and the structure of the general purpose program CACS are described. Author

**A86-23879#**

**MEASUREMENT OF TURBINE BLADE TEMPERATURE USING PYROMETER**

H. CHENG and C. DU (Shenyang Aeroengine Research Institute, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(ASME PAPER 85-IGT-78)

This paper presents the study of application of a self-made turbine blade pyrometer to measuring rotating turbine blade temperatures in a bed testing aeroengine. The study includes the temperature measuring principle and the pyrometer system; installation and adjustment of the double ball-floating type configuration optical head which goes through four different high temperatures bulkheads; and measurement of three kinds of temperature (the average blade temperature Ta, the average peak blade temperature Tap, and the maximum peak blade temperature Tmp) for all rotor blades of the turbine first stage. The experimental data analysis reveals that the first attempt of application of this pyrometer is successful. The measurement errors in the temperature range of 550-1200 C are within + or - 1 percent of calculated blade temperatures. Author

**A86-23904#**

**A SURVEY OF ACCELERATED VIBRATORY FATIGUE TEST METHOD OF AERO-ENGINE COMPRESSOR BLADE**

T.-Y. WU and Q.-X. LU (Nanjing Aeronautical Institute, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 6 p. refs
(ASME PAPER 85-IGT-105)

In this paper, a new accelerated fatigue test method based on Miner's Law is advanced, which is used for vibratory fatigue test of aeroengine compressor blading. By using this method, a sample life distribution can be obtained, and it saves time by about 50-60 percent. This approach is validated by experiments, and the test data are compared by two statistical methods, namely, the F-test and t-test. Author

**A86-23909#**

**THE SOLUTION OF THE THERMAL ELASTIC-PLASTIC PROBLEM OF TURBINE DISK BY THE INCREMENTAL FINITE ELEMENT METHOD**

S.-J. WEN (Shanghai University of Engineering and Technology, People's Republic of China), O. CHANG, and J.-Y. FANG (Fudan University, Shanghai, People's Republic of China) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 6 p. refs
(ASME PAPER 85-IGT-112)

In this paper, a stress analysis method and a computation program of the solution for the thermal elastic-plastic problem of a turbine disk in an aeroengine are presented by incremental finite element method. The method, which is suitable for the axisymmetric disk in the gas turbine, compressor, and steam turbine as well, may be used to compute the stress and displacement of a turbine disk at its thermal elastic or thermal elastic-plastic stage, its cracking revolving speed and limit load capacity, and the part which enters into the plastic zone first. The method may be used to compute the leading and unleading process, residual stress, and displacement, as well. It is important to analyze the strength of the turbine disk and its fracture characteristics. Author

**A86-23933#**

**THE USE OF LASERS IN GAS TURBINE MANUFACTURING**

D. S. DUVALL (United Technologies Corp., Pratt and Whitney Div., East Hartford, CT) ASME, Chinese Society of Aeronautics and Astronautics, and China National Aero-Technology Import and Export Corp., Beijing International Gas Turbine Symposium and Exposition, Beijing, People's Republic of China, Sept. 1-7, 1985. 7 p. refs
(ASME PAPER 85-IGT-141)

The laser is being increasingly used as a manufacturing tool in the fabrication of aircraft gas turbine engine components. Both solid-state pulsed and gas continuous-wave lasers are employed for a variety of manufacturing tasks including welding, cutting, hole drilling, surface alloying, and marking of parts for identification. In these applications, the laser provides increased productivity and reduced cost compared to conventional methods. Examples of specific uses of the laser in gas turbine fabrication are described along with the benefits achieved. Metallurgical effects associated with various laser processes are also discussed. Author

**A86-23944#**

**THE EFFECT OF COMPRESSIBILITY ON SLENDER VORTICES [DER EINFLUSS DER KOMPRESSIBILITAET AUF SCHLANKE WIRBEL]**

E. KRAUSE Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 27, 1985, p. 19-23. In German. refs

There is no or little information regarding studies concerned with the effect of compressibility on slender vortices and the vortex breakdown in compressible flows. However, detailed knowledge of the breakdown process in compressible flows is required to avoid uncontrollable flight conditions, in particular, in the case of aircraft with delta wings. In the present study, the attempt is made to provide a representation of the influence of compressibility on slender vortices. The employed approximation of the equations of motion makes it impossible to calculate the position of the breakdown point accurately. However, it is still feasible to determine in the analysis the most important differences with respect to the incompressible flow. A summary is provided of the results reported by Krause (1983, 1985) for slender vortices in incompressible flow, and the obtained corresponding relations for compressible flows are discussed. It is found that the breakdown of slender vortices in compressible flow is less rapid than in incompressible flow. G.R.

**A86-23951**

### COMPARISON OF TWO TARGET CLASSIFICATION TECHNIQUES

J. S. CHEN and E. K. WALTON (Ohio State University, Columbus) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-22, Jan. 1986, p. 15-22. Research supported by the Ohio State University Research Foundation. refs
(Contract N00014-82-K-0037)

Radar target classification techniques based on backscatter measurements in the resonance region (1.0-20.0 MHz) are discussed. Attention is given to two novel methods currently being tested at the radar range of Ohio State University. The methods include: (1) the nearest neighbor (NN) algorithm for determining the radar cross section (RCS) magnitude and range corrected phase at various operating frequencies; and (2) an inverse Fourier transformation of the complex multifrequency radar returns of the time domain, followed by cross correlation analysis. Comparisons are made of the performance of the two techniques as a function of signal-to-error noise ratio for different types of processing. The results of the comparison are discussed in detail. I.H.

**A86-24230#**

### THE VISCOELASTIC DAMPING TECHNOLOGY DESIGN GUIDE FOR AEROSPACE STRUCTURES

V. R. MILLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), M. L. DRAKE (Dayton, University, OH), and J. SOOVERE (Lockheed-California Co., Burbank) ASME, Design Engineering Technical Conference, Cincinnati, OH, Sept. 10-13, 1985. 4 p. USAF-sponsored research.
(ASME PAPER 85-DET-104)

Viscoelastic damping technology has reached a state of maturity in which it serves as a design tool for the effective solution of resonant vibration problems. Unexpected vibration problems can therefore be solved without resort to extensive structural design modifications. A viscoelastic damping design guide is now available as Air Force Wright Aeronautical Labs TR-84-3089, 'The viscoelastic damping technology design guide for aerospace structures'. O.C.

**A86-24231#**

### INTERACTIVE MODAL IMAGING PROCESS FOR VIBRATING STRUCTURES

D. K. RAO (USAF, Materials Laboratory, Wright-Patterson AFB, OH) ASME, Design Engineering Technical Conference, Cincinnati, OH, Sept. 10-13, 1985. 12 p. Research sponsored by the National Research Council. refs
(ASME PAPER 85-DET-110)

A major objective of Experimental Modal Analysis is to extract and display mode shapes of a structure. This paper presents development of a mode measurement method, called Modal Imaging Process (MIP). This is an on-line process that develops and displays the Modal Image of a Vibrating Structure directly. It uses roving vibration transducer(s) to measure amplitude and phase of vibrations at selected Surface Points. These transducers are integrated into a microcomputer which instantaneously creates/updates the Modal Image of the structure. Display of direct image of the vibrating structure will help the user to locate and correct any measurement errors on the spot, and view its true mode shape. Application of MIP to few aerospace structures are presented, and mode shapes measured by this method are compared with those displayed by offline FFT techniques. The MIP software is written in FORTRAN so that it can run on most of the inexpensive microcomputers. Author

**A86-24236#**

### RESULTS OF RECENT RESEARCH ON DAMPED FAN BLADES

M. F. KLUESENER (Dayton, University, OH) and D. R. OETH (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) ASME, Design Engineering Technical Conference, Cincinnati, OH, Sept. 10-13, 1985. 8 p. refs
(Contract F33615-82-C-5022)
(ASME PAPER 85-DET-133)

Gas turbine engine airfoil high cycle fatigue failures are the result of forced or flutter-induced vibration. These vibration problems have been solved in some cases by using part-span shrouds. Recent advances in vibration damping technology indicate that additive damping techniques are a promising alternative to part-span shrouds. Evaluations were made of techniques and materials for providing high levels of intrinsic damping in the vibration modes of a gas turbine engine fan blade such that the part-span shrouds could be eliminated. An airfoil external constrained layer damping system was designed for the presently shrouded TF41 engine first-stage LP compressor blade to provide an additional system damping loss factor of 0.017, the analytically determined minimum required for flutter-free operation and acceptable forced response levels. An external damping system was applied to the blade, and the levels of modal damping achieved were experimentally measured. Author

**A86-24246#**

### AUTOPARAMETRIC VIBRATION OF COUPLED BEAMS UNDER RANDOM SUPPORT MOTION

R. A. IBRAHIM (Texas Tech University, Lubbock) and H. HEO ASME, Design Engineering Technical Conference, Cincinnati, OH, Sept. 10-13, 1985. 8 p. refs
(Contract AF-AFOSR-85-0008)
(ASME PAPER 85-DET-184)

The dynamic response of a two degree-of-freedom system with autoparametric coupling to a wide band random excitation is investigated. The analytical modeling includes quadratic non-linearity, and a general first order differential equation of the moments of any order is derived. It is found that the movement equations form an infinite hierarchy set which is closed via two different closure methods. These are the Gaussian closure and the non-Gaussian closure schemes. The Gaussian closure solution shows that the system does not reach a stationary response while the non-Gaussian closure solution gives a complete stationary steady state response. In both cases the response is obtained in the neighborhood of the autoparametric internal resonance condition for various system parameters. Author

**A86-24646#**

### MEASUREMENTS ACCURACY WITH 3D LASER VELOCIMETRY

A. BOUTIER, D. PAGAN, and D. SOULEVANT (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Laser Anemometry - Advances and Application, Manchester, England, Dec. 16-18, 1985) ONERA, TP, no. 1985-171, 1985, 15 p. refs
(ONERA, TP NO. 1985-171)

Accuracy problems that arise in connection with the simultaneous measurement of the three local velocity components using a 3D laser velocimeter (LV), when the 3rd component is obtained by combining two copianar components, are examined. The various ways to set up a 3D LV are summarized, and a particular fringe, three-color LV, with signals processed by counters, is described in more detail. Sources of error are analyzed, and ways to minimize them are considered. The successful application of an existing LV to study vortex breakdown downstream of a delta wing is reported. C.D.

**A86-24663**
**HIGH-TEMPERATURE COMPOSITE DUCTS**
G. F. HOWARTH, G. GLINECKI (Martin Marietta Corp., Baltimore, MD), and B. TAMBUSSI (Composite Structures Technology, Inc., Cherry Hill, NJ) Society of Manufacturing Engineers, Conference on Fabricating Composites, Hartford, CT, June 11-13, 1985. 12 p.
(SME PAPER MF85-501)

The advantages and problems involved in the use of composites in aerospace applications are discussed. The problem of design is addressed, identifying the most important parameters. The individual steps involved in a tooling system analysis are given, and a materials/process matrix is presented and discussed. The advantages of graphite/polyimide for aerospace applications are examined. C.D.

**A86-24667**
**ROBOTIC APPLICATIONS TO AUTOMATED COMPOSITE AIRCRAFT COMPONENT MANUFACTURING**
B. SARH (Rohr Industries, Inc., Riverside, CA) Society of Manufacturing Engineers, Conference on Fabricating Composites, Hartford, CT, June 11-13, 1985. 18 p.
(SME PAPER MF85-506)

This paper considers robotic applications in aircraft prepreg composite structure fabrication. The process steps involved in automated prepreg production are described with a focus on process efficiency. For a typical composite structural shell, the number of different preprep pieces used is compared to the number of parts involved in a conventional metal structure, and the potential for automated production is shown. Specific process times and efficiencies for the process steps in fabricating a composite aircraft shell are calculated. Author

**A86-24828**
**ELECTRIC POWER MANAGEMENT AND DISTRIBUTION FOR AIR AND SPACE APPLICATIONS**
B. MEHL and E. HENDERSON (Sundstrand Corp., Rockford, IL) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.374-1.381. refs

The historical growth of electric power systems for aircraft and space applications is briefly reviewed, and the technical issues involved in electric power management and distribution are discussed. The discussion covers bus architectures, power management components, power system controls, autonomous power management, transient reduction, and autonomous system reconfiguration. Particular attention is given to advanced electric power systems concepts and alternative implementations. V.L.

**A86-24829**
**EFFICIENTLY MEETING ELECTRIC POWER NEEDS FOR FUTURE AIRCRAFT**
I. S. MEHDI and P. J. LEONG (Boeing Military Airplane Co., Seattle, WA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.382-1.387.

Electric power in modern aircraft is becoming more and more important not only for powering essential systems but also to keep the aircraft in control. Stability Augumentation Systems in fly-by-wire aircraft cannot tolerate power interruptions as loss of power would cause loss of control of the aircraft itself. This paper describes the needs of the avionics and flight control systems in terms of quantity and quality of electric power required. Special requirements such as uninterruptible electric power and ultra-high reliability will be defined. These requirements will have to be met by incorporation of special features in the power generation and distribution systems, the control and protection and the utilization systems. It is significantly easier to provide uninterruptibility in dc-powered equipment. Author

**A86-24830*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A NEW DIRECTION IN ENERGY CONVERSION - THE ALL-ELECTRIC AIRCRAFT**
C. R. SPITZER (NASA, Langley Research Center, Hampton, VA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.388-1.393. refs

This paper reviews recent studies of all-electric aircraft that use electric-only secondary power and flight critical fly-by-wire flight controls, and brings to the attention of the power system designer the intrinsic advantages of such aircraft. The all-electric aircraft is made possible by the development of rare earth magnet materials and fault tolerant systems technologies. Recent studies have shown all-electric aircraft to be more efficient than conventional designs and offer substantial operating costs reductions. Compared to present aircraft, an all-electric transport can save at least 10 percent in fuel burn. The cornerstone of an all-electric aircraft is the electric secondary power system. This paper reviews the major features of flight critical electric secondary power systems. Research required to lay the foundation for an all-electric aircraft is briefly discussed. Author

**A86-25016**
**COMMUNICATION WITH LAND VEHICLES AND AIRCRAFT VIA SATELLITE [KOMMUNIKATION MIT LANDFAHRZEUGEN UND FLUGZEUGEN UEBER SATELLIT]**
J. HAGENAUER and E. LUTZ (DFVLR, Institut fuer Nachrichtentechnik, Oberpfaffenhofen, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1985, p. 15-20. In German.

The present article is concerned with the feasibility to utilize satellites as a basis for large-area or even worldwide networks providing communication services to mobile participants in land vehicles, on ships, in aircraft, and in emergency situations. The current situation with respect to the considered communication services is examined, taking into account also the International Maritime Satellite Organization Inmarsat. An antenna with a size of about 10 cm would be sufficient for the smallest terminal on a ship. Antennas with such small dimensions would also be suitable for a use in the case of aircraft, automobiles, and emergency messages. Problems are related to the development of cost-efficient equipment; and research conducted by the DFVLR to overcome these problems is discussed. Developments regarding the satellite-aided communication with land vehicles are described, along with the advantages of satellite-aided communication in the case of aircraft. An improvement of communication with aircraft over the North Atlantic would make it possible to increase air traffic density and save fuel. G.R.

**A86-25751**
**EQUIVALENT STIFFNESS AND DAMPING COEFFICIENTS FOR SQUEEZE FILM DAMPERS**
E. J. HAHN (New South Wales, University, Kensington, Australia) IN: International Conference on Vibrations in Rotating Machinery, 3rd, Heslington, England, September 11-13, 1984, Proceedings . London, Mechanical Engineering Publications, Ltd., 1984, p. 507-514. refs

In aircraft engines, squeeze film dampers are increasingly used to achieve stabilization or appropriate vibration attenuation. Difficulties regarding the conduction of design studies can arise, because the damper forces are nonlinear functions of velocity and displacement. The present study is, therefore concerned with a general technique for linearizing the nonlinear element forces. The approach adopted for evaluating equivalent stiffness and damping coefficients employs energy dissipation and energy storage-release concepts. Attention is given to equivalent stiffness and damping coefficients, centrally preloaded dampers, a damper without centralizing spring - rigid rotor, and the application of the considered procedure to a general multimass rotor bearing system with a squeeze film damper. G.R.

**A86-25865**
**GYROSCOPES MAY CEASE SPINNING**
G. J. MARTIN (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IEEE Spectrum (ISSN 0018-9235), vol. 23, Feb. 1986, p. 48-53. refs

Laser gyroscopes have advantages compared to mechanical gyroscopes. Thus, they are more rugged and reliable, and, therefore, offer lower life-cycle costs. They are not yet more accurate than high-quality mechanical systems, but they have excellent development potential. Problems which can arise in the case of the spinning-rotor systems are related to their sensitivity to gravitational fields in the increasingly high-g environment of modern military aircraft. Optically based systems, on the other hand, have, in principle, no gravitational sensitivity and are in addition highly linear over a large dynamic range. The principles of operation of ring laser gyros (RLG) are discussed, taking into account the utilization of the Sagnac effect. Attention is given to the approaches found to overcome a number of engineering difficulties which arose in connection with the construction of RLG, techniques for limiting laser beam competition, aspects of geometry, and the current state of the art. G.R.

**A86-26111#**
**THREE COMPONENT HOT-WIRE MEASUREMENTS IN THE WAKE OF A ROTOR MODEL**
S. DE PONTE, A. BARON (Milano, Politecnico, Milan, Italy), and B. MIGNEMI (Italtel - Societa Italiana Telecomunicazioni S.p.A., Milan, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 10 p.

According to previous experience in hot-wire measurements in the flowfield of a rotor model in hover conditions, the paper describes problems connected with experiments of this kind and their possible solutions. In particular, it deals with the reliability of directional measurements related to triple hot-wire probes, the data validation procedure and validity of experimental results, the choice of probe orientation and some useful way of presenting the results in graphical form. Furthermore, the paper discusses one way to analyze the signal in statistical form in order to reconstruct turbulent or vortical structures without the usual 'smoothing' associated with ensemble averages due to the long-period 'wandering' of the wake. Author

**A86-26121#**
**COMPOSITES IN THE DEVELOPMENT OF AGUSTA HELICOPTERS**
F. GAMBARO and F. NATALIZIA (Elicotteri Meridionali S.p.A., Frosinone, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p.

A development status and production capabilities assessment is presented for a state-of-the-art helicopter composite rotor manufacturer's highly automated development, fabrication and inspection facilities. Representative filament-wound and laminate composite products include a main rotor hub grip assembly for the A129 antitank helicopter, and the main and tail rotor blades, main rotor hub components, and tail unit assemblies of the EH101 military helicopter. The production plant encompasses warehouse, clean room, metal chemical treatment, finishing, thermal treatment, design office, and experimentation departments. O.C.

**A86-26122#**
**MANUFACTURING CONTROL OVER THE REPRODUCTION OF HIGH INTEGRITY PARTS - A WAY TO IMPROVE THE SAFETY OF AERONAUTICAL PRODUCTS**
C. BIGLIETTO and C. ARCARI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 19 p.

It is presently noted that close compliance with dimensional and specifications requirements in the production of helicopter components sometimes is not enough to ensure their interchangeability. It is recommended that the manufacturing operation sheets of a given component be closely monitored over their history in order to evaluate the effect of apparently minor changes. In addition, the original manufacturer must be considered the sole adequate resupply source for the most vital components. O.C.

**A86-26125#**
**ELASTOMERIC ROD END BEARINGS - A SOLUTION FOR IMPROVING RELIABILITY AND MAINTAINABILITY**
F. E. STAPLES, P. J. JONES, and W. E. SCHMIDT (Lord Corp., Aerospace Products Div., Erie, PA) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 25 p.

The extension of elastomeric bearing technology to rod ends, which is desirable for aircraft applications, especially control systems on helicopter rotors, is discussed. Elastomeric bearing development and the need for elastomeric rod ends are reviewed, and the types of elastomeric rod ends are described. The design and service advantages gained by elastomeric rod ends are addressed, and elastomeric rod end design and design refinement are considered. Service considerations and in-service applications of elastomeric rod ends are examined. C.D.

**A86-26155#**
**THE DESIGN OF AN ADVANCED ENGINEERING GEARBOX**
H. COCKING (Westland, PLC, Helicopter and Hovercraft Group, Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 17 p. Research supported by the Ministry of Defence of England.

Equations are presented which show that gear and gearbox weights are proportional to the torque on the gear and gearbox respectively. An element of these equations called the 'configuration factor' can be derived from the gearing layout, and then used as a comparison of gearbox weights. Using this configuration factor, three features essential to any low weight gearbox have been identified. All triple reduction layouts, many using these three factors, have been analyzed using the configuration factor technique and a particular low weight configuration identified. The weight of this new configuration has been predicted and verified by traditional means and shows a 38 percent weight saving when compared to the existing Sea King Gearbox. Development programs are now nearing completion to enable this configuration to be incorporated into improved versions of certain current helicopters and new designs. Author

**N86-18286#** Joint Publications Research Service, Arlington, Va.
**AVIAREMONT'S EFFORTS TO INTRODUCE LASER TECHNOLOGY**
Y. KOLESNIKOV *In its* USSR Report: Transportation (JPRS-UTR-85-014) p 5-7 4 Dec. 1985 Transl. into ENGLISH from Vozdushnyy Transport (Moscow, USSR), 17 Sep. 1985 p 3
Avail: NTIS HC A04

To reduce the high cost of aircraft parts replacement, the Aviaremont Plant of Irkutsk plans to use lasers to resurface worn parts to save them from the scrap heap. Author

**N86-18370#** Consiglio Nazionale delle Ricerche, Florence (Italy). Ist. di Ricerca sulle Onde Elettromagnetiche.
**REMOTE SENSING OF OIL ON SEA: LIDAR AND PASSIVE IR EXPERIMENTS**
F. CASTAGNOLI, G. CECCHI, L. PANTANI, I. PIPPI, B. RADICATI, C. SUSINI, P. MAZZINGHI, and A. BARBARO *In* ESA Proceedings of EARSeL/ESA Symposium on European Remote Sensing Opportunities: Systems, Sensors, and Applications p 121-126 Jun. 1985 refs
Avail: NTIS HC A12/MF A01

A compact system for detecting and monitoring oil pollution on the sea from light aircraft using passive infrared remote sensing was developed. Lidar marine environment and pollution monitoring potential was assessed in the laboratory. The low-power airborne system is suitable for day and night operations in quite good weather. It performs a real time detection of the oil, a mapping of the spill, and an identification of its thickest parts. A suitable Lidar system can be composed by an XeCl excimer laser with small dimensions, a low energy consumption, and 50 mJ energy per pulse. The detection system does not require an optical multichannel analyzer, but it is possible to operate with only three interferential filters: one for Raman scattering signal, the others for fluorescence signals, which are sufficient to identify the oil class. Author (ESA)

**N86-18588#** Naval Aerospace Medical Research Lab., Pensacola, Fla.

**THE EFFECTS OF VOCAL VERSUS MANUAL RESPONSE MODALITIES ON MULTI-TASK PERFORMANCE Interim Report**

G. R. GRIFFIN and J. D. MOSKO Feb. 1985 17 p
(Contract F58-528)
(AD-A159830; NAMRL-1312) Avail: NTIS HC A02/MF A01 CSCL 05J

The increasing complexity of display and control instrumentation in modern high performance aircraft has the potential to overload the human operator and result in diminished system performance. Interactive voice technology has been proposed as a method to reduce the high workload placed on the pilots of military aircraft. This report presents the results of an experiment designed to evaluate the effects on human performance of vocal versus manual response modalities on single and multiple tasks simulating some conditions of flight. Results indicated a significant increase in performance precision on a psychomotor task when a vocal, rather than a manual response mode was used on the simultaneous performance of multiple tasks. These results suggest that human performance on visually oriented multiple tasks requiring simultaneous execution may be improved if some of the work effort can be performed using a vocal input/output. GRA

**N86-18599#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**EFFECTS OF NOISE AND WORKLOAD ON A COMMUNICATION TASK**

D. H. ORRELL, II May 1985 81 p
(AD-A160743; AFIT/CI/NR-85-101T) Avail: NTIS HC A05/MF A01 CSCL 17B

Communication is of vital importance in the cockpit today. It is essential for pilots to be able to understand the messages sent to them. A major requirement of any aircraft voice communication system is the ability to deliver intelligible speech. In a loose sense, intelligibility may be defined as the understanding of spoken words (Webster, 1979). Several language factors affect intelligibility including vocabulary size, word frequency (familiarity) effects, number of response alternatives, number of syllables, phonetic elements and context (Webster, 1972). Other external considerations include equipment or design features and environment (Webster and Allen, 1972). With such a wide range of sources of influence, it is easy to understand the need for a reliable intelligibility test. One such test found to be particularly useful in studying the effects of aircraft noise has been the Modified Ryhme Test (MRT). GRA

**N86-18630#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

**A COMPARATIVE EVALUATION OF THE RELIABILITY IMPROVEMENT IN LINE REPLACEABLE UNITS WARRANTED UNDER THE F-16 RELIABILITY IMPROVEMENT WARRANTY M.S. Thesis**

S. J. LEMKE Sep. 1985 98 p
(AD-A160830; AFIT/GLM/LSP/85S-44) Avail: NTIS HC A05/MF A01 CSCL 09C

This thesis examined the effects a reliability improvement warranty (RIW) had on the actual operational reliability of the warranted avionics equipment. To accomplish this, the most comprehensive DOD application of RIW to date, the F-16 RIW, was investigated. This study was designed to answer the question of whether or not a warranted weapons system was significantly more reliable than it would have been without the warranty. Specifically, the observed mean flight hours between failures (MFHBFs) and the observed reliability growths of the warranted F-16 equipment were compared to those of functionally similar non-warranted F-15 equipment. Also, the reliability growth of the F-16 warranted equipment was compared to that of other non-warranted F-16 equipment. The AMSAA Reliability Growth Model was used as a basis for the reliability growth analyses. Comparable life cycle time periods for each aircraft were studied, using AFM 66-1 D056 failure and flight time data. The results of the investigation indicated that, in general, the observed MFHBFs of the F-16 warranted equipment were statistically greater than the MFHBFs of the equivalent F-15 equipment. The same could not be concluded for the reliability growths of the F-16 and equivalent F-15 equipment. However, the reliability growth of the warranted F-16 equipment was found to be statistically greater than the reliability growth of the non-warranted F-16 equipment. Author (GRA)

**N86-18699#** California Univ., Irvine. Dept. of Mechanical Engineering.

**AIRCRAFT MEASUREMENTS AND COORDINATION IN FASINEX Semiannual Progress Report**

C. FRIEHE 10 Jul. 1985 6 p
(Contract N00014-85-K-0190)
(AD-A160789) Avail: NTIS HC A02/MF A01 CSCL 01C

As of July 10, 1985, the following progress was made on the proposal work: (1) wind and turbulence measurements on NRL Navy RP3A aircraft, BUNO 149670: (a) Radome pressure transducers purchased and installed with radome tubing, and wiring, test flights were performed to determine if pressure signals are active, (b) data system for aircraft tested, borrowed from National Center for Atmospheric Research (NCAR), Boulder, Colorado and shipped to NRL and made operational in the laboratory; (c) various environmental sensors obtained from USN China Lake, CA, for the NRL RP3A: Barnes infrared meterological radiometers; parts of dew point system; (2) FASINEX Aircraft Coordination: (a) site visit made to NAS Bermuda, facilities will be provided for transient FASINEX aircraft by NAS Bermuda; (b) cooperative agreement for joint use of NCAR Electra research aircraft by GALE and FASINEX projects worked out; (c) attended GALE planning meeting as FASINEX representative. GRA

**N86-18728** Department of the Air Force, Washington, D.C.

**MODULAR AIR SHUT-OFF VALVE Patent**

J. J. BUCKLEY and W. T. SCOTT, inventors (to Air Force) 13 Aug. 1985 6 p Supersedes AD-D010489
(AD-D011935; US-PATENT-4,534,538;
US-PATENT-APPL-SN-512083; US-PATENT-CLASS-251-62)
Avail: US Patent and Trademark Office CSCL 13A

A modular air shut-off valve, particularly useful within the air conditioning environmental control system of an aircraft, is provided. It consists of a housing sized for insertion into a duct of the air conditioning system, a vane pivotally mounted within the housing for pivotal movement between open and closed positions and having flexible portions along its edges contacting the housing in the closed position for providing a resilient seal and to allow pressure relief in the event of overpressure within the duct. Author (GRA)

**N86-19490** Ohio State Univ., Columbus.

**PERFORMANCE OF RESONANT RADAR TARGET IDENTIFICATION ALGORITHMS USING INTRA-CLASS WEIGHTING FUNCTIONS Ph.D. Thesis**

A. MUSTAFA 1985 226 p
Avail: Univ. Microfilms Order No. DA8518995

The use of calibrated resonant-region radar cross section (RCS) measurements of targets for the classification of large aircraft is discussed. Errors in the RCS estimate of full scale aircraft flying over an ocean, introduced by the ionospheric variability and the sea conditions were studied. The Weighted Target Representative

(WTR) classification algorithm was developed, implemented, tested and compared with the nearest neighbor (NN) algorithm. The WTR-algorithm has a low sensitivity to the uncertainty in the aspect angle of the unknown target returns. In addition, this algorithm was based on the development of a new catalog of representative data which reduces the storage requirements and increases the computational efficiency of the classification system compared to the NN-algorithm. Experiments were designed to study and evaluate the characteristics of the WTR- and the NN-algorithms, investigate the classifiability of targets and study the relative behavior of the number of misclassifications as a function of the target backscatter features. The classification results and statistics were shown in the form of performance curves, performance tables and confusion tables. Author

**N86-19583#** National Aerospace Lab., Tokyo (Japan).

**STUDY ON THE DIGITAL POSITION TRANSDUCER WITH OPTICAL TIME-DELAY PULSE**

M. MAYANAGI Sep. 1985 40 p refs In JAPANESE; ENGLISH summary

(NAS-TR-878; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A rotary optical position transducer employing a pulse technique time-multiplexor has been studied during the development of a Fly-By-Light (FBL) for the aircraft control system, the aim of which is to offer inherent resistance to environments of electromagnetic interference (EMI), electromagntic pulse (EMP) and lightening. The conventional absolute-type optical digital transducer causes difficulty in the interface technique between the transducer and other devices such as a computer. The transducer system described in this paper, which consists of a rotary position transducer unit, a fiber-optic cable, a light source unit, and an electronics interface unit, can improve this interface technique. The rotary transducer unit is an electrically passive device that is connected through optical fibers to the light source unit and the electronics interface unit, and that has many advantages of fiber-optic techniques. This paper studies basic problems in the development of the rotary transducer system. In particular, a basis for optimizing illumination irradiance and photo-detector characteristics is given, and the intrinsic performance of the transducer is quantitatively examined. Author 21

**N86-19642** Engineering Sciences Data Unit, London (England).

**GROWTH OF CRACKS UNDER CONSTANT AMPLITUDE FATIGUE LOADING: EXAMPLE CALCULATIONS**

Mar. 1985 19 p refs Submitted for publication Sponsored in part by the Royal Aeronautical Society, London, England

(ESDU-84001; ISBN-0-85679-464-3; ISSN-0141-3996) Avail: ESDU

ESDU 84001 shows how crack growth data, such as those in this Sub-series, are used in practical situations; it provides two fully-worked examples using representative structural components to estimate the number of cycles to a specified crack length. The example shows the effect of a series of equally pitched riveted stiffeners on the progress of a crack across a sheet. Author

**N86-19656#** National Aeronautical Lab., Bangalore (India). Materials Science Div.

**FATIGUE CRACK PROPAGATION UNDER SPECTRUM LOADING**

R. SUNDER Mar. 1985 21 p refs

(NAL-TM-MT-8502) Avail: NTIS HC A02/MF A01

This project involved development of a method to predict the fatigue crack propagation process in thin-walled aircraft structural components under flight-by-flight loading. Extensive experimental test results provided the input for software development. They yielded evidence pointing to the complex nature of crack growth under spectrum loading and also provided the basis for procedures adopted for life prediction. A simple engineering method is proposed for estimating fatigue crack propagation life under random loading. Predictions are based on test data obtained under constant amplitude loading. Prediction accuracy favourably compares with that of available techniques. Computation time is extremely small, enabling the use of desktop computer for life predictions. Author

**N86-19657#** National Aeronautical Lab., Tokyo (Japan).

**FUNDAMENTAL INVESTIGATION ON THE IMPACT STRENGTH OF HOLLOW FAN BLADES**

T. IKEDA, T. MIYACHI, and Y. SOFUE Sep. 1985 23 p refs In JAPANESE; ENGLISH summary

(NAL-TR-879; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

Models of hollow fan blades were made and tested to prove that their strength is sufficient for use in real engines. The hollow blades were fabricated by diffusion bonding of two titanium alloy (6Al-4V-Ti) plates, one of which had three spanwise stiffners and the other being flat plate. The model was a non-twisted tapered blade. Impact tests were carried out on the hollow fan blade models in which the ingestion of a 1.5 pound bird was simulated. Solid blades with the same external form were also tested by similar methds for comparison. The results of these tests show that properly designed hollow blades have sufficient stiffness and strength for use as fan blades in the turbo-fan engine. Author

**N86-19661*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**APPLICATION OF MATHEMATICAL OPTIMIZATION PROCEDURES TO A STRUCTURAL MODEL OF A LARGE FINITE-ELEMENT WING**

J. L. WALSH Jan. 1986 43 p refs

(NASA-TM-87597; L-15930; NAS 1.15:87597) Avail: NTIS HC A03/MF A01 CSCL 20K

An optimization system is described that consists of the finite-element analysis program known as Engineering Analysis Language (EAL), the CONMIN optimization program, and a piecewise linear analysis. The optimization analysis system (OPTEAL) is used to minimize the mass of a transport wing subject to stress constraints for two static load conditions. The optimization procedure and the optimization analysis system (OPTEAL) are described and the optiomized results with fully stressed design results compared. Author

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# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-23289**

**AIRCRAFT FLOW EFFECTS ON CLOUD DROP IMAGES AND CONCENTRATIONS MEASURED BY THE NAE TWIN OTTER**

A. M. DRUMMOND and J. I. MACPHERSON (National Aeronautical Establishment, Flight Research Laboratory, Ottawa, Canada) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 2, Dec. 1985, p. 633-643. refs

A theoretical model for the local flow velocity ahead of the wing quarter-chord point on the National Aeronautical Establishment Twin Otter has been developed and experimentally verified by flight measurements using a pitot-static equipped Particle Measuring Systems (PMS) canister. This flow velocity model was used to calculate drop trajectories and the resulting airflow effects on drop images and concentrations. Results indicate that drop images and concentrations measured by the Twin Otter are distorted in the worst case by no more than 25 percent for an unusually high aircraft lift coefficient of 0.79, and by only a few percent for lower values of this coefficient typical of normal flight. A method to correct water drop images and concentrations is described and results for a PMS probe mounted at one underwing station are presented. Author

**A86-23291**
**COMPARISON OF SEA SURFACE TEMPERATURES OBTAINED FROM AN AIRCRAFT USING REMOTE AND DIRECT SENSING TECHNIQUES**
P. A. SPYERS-DURAN (National Center for Atmospheric Research, Boulder, CO) and C. D. WINANT (California, University, La Jolla) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 2, Dec. 1985, p. 667-671. refs
(Contract NSF OCE-83-10639)

A comparison of sea surface temperatures is made between aircraft precision radiation thermometer (PRT-5) and aircraft deployed expendable bathythermographs (AXBT) drops. These observations were obtained using the NCAR King Air aircraft for an experiment in the Gulf of California during March 1984. The average difference between the sea surface temperatures reported by the first temperature observed in each AXBT drop and the PRT-5 is -0.07 C with a standard deviation of 0.57 C. The difference in temperature between the two observations increases at lower wind speeds. Based on 116 case studies, differences of 1-2 C exist between the surface and the upper meter of the ocean when wind speeds are less than 5 m/s. Author

**A86-23292**
**DEDUCTION OF VERTICAL MOTION IN THE ATMOSPHERE FROM AIRCRAFT MEASUREMENTS**
F. J. KOPP (South Dakota School of Mines and Technology, Rapid City) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 2, Dec. 1985, p. 684-688. refs
(Contract NSF ATM-80-25598; NSF ATM-83-11145)

Equations for deducing the vertical motion of air based on aircraft measurements are presented along with derivations. The equations are based on the aircraft equations of motion, but due to different assumptions, the resulting equations are quite different. The equations are then applied to the same aircraft data for comparison. Considerably different results are obtained. The equation based on Lenschow's work is believed to give the most reliable results. Author

**A86-24631#**
**PROGRESS IN THE ANALYSIS OF ATMOSPHERIC TURBULENCE [PROGRES DANS LA CONNAISSANCE DE LA TURBULENCE ATMOSPHERIQUE]**
G. COUPRY (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Meeting, 61st, Oberammergau, West Germany, Sept. 8-13, 1985) ONERA, TP, no. 1985-164, 1985, 22 p. In French. refs
(ONERA, TP NO. 1985-164)

The report deals with measurement of time histories of turbulence, made by specially equipped aircraft, as well as with statistics of events deduced from a large number of commercial flights. A critical analysis of the methods used to reduce the flight data is developed, and proposals for improvements are suggested. It is shown that patches of turbulence for which a given level is exceeded are distributed following a Poisson distribution. Author

**A86-26140#**
**DYNAMIC RESPONSE OF WINDTURBINE TO YAWED WIND**
A. AZUMA, S. SAITO (Tokyo, University, Japan), and F. NAKAMURA (Toyota Motor Corp., Aichi, Japan) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 18 p.

Dynamic response of a two-bladed windturbine to yawed wind is analyzed by means of the local circulation method. The dynamic system is considered to consist of blade deformation, rotor rotational motion and yawing motion of the windturbine. The amplitude of the 2-P vibration in the bending moment and the rotor torque are more significant in the change of wind direction than in that of wind speed. The exemplified windturbine can follow the change of wind direction with fairly small response time. The inertial forces and moments are much smaller than the aerodynamic components because of the high rigidity of the present rotor. Author

**A86-26175**
**NUCLEATION OF ICE CRYSTALS IN SUPERCOOLED CLOUDS CAUSED BY PASSAGE OF AN AIRPLANE**
B. VONNEGUT (New York, State University, Albany) Journal of Climate and Applied Meteorology (ISSN 0733-3021), vol. 25, Jan. 1986, p. 98. refs
(Contract NSF ATM-79-21080; N00014-80-C-0312)

The proposed hypothesis of Vonnegut (1948) and Ludlum (1958) which states that cooling produced by adiabatic expansion of air disturbed by an aircraft causes an increase in ice crystal concentrations is examined. Temperature changes in the vortices produced at the tips of wings or propeller blades are estimated; an increase in the rate of crystal production after an increase in the tip speed of the propeller should be detected if aerodynamic cooling causes nucleation of ice crystals. The effects of aerodynamic characteristics of the blades and the blade angle of attack on temperature changes are investigated. I.F.

**N86-18795#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**DESIGN METHOD FOR THE CALCULATION OF PERFORMANCES AND FLAP MOVEMENT OF FLEXIBLE WIND TURBINE BLADES [ONTWERPMETHODE VOOR DE BEREKENING VAN PRESTATIES EN KLAPBEWEGING VAN FLEXIBELE WINDTURBINEBLADEN]**
T. VANHOLTEN and J. L. KOOMAN Feb. 1983 42 p refs
In DUTCH
(VTH-M-453) Avail: NTIS HC A03/MF A01

Performances, flap movements and loads of so-called flexible wind turbine blade were calculated in cases of right flow, flow with a velocity gradient, and oblique flow. The helicopter rotor based calculation method is simplified, and proves useful for first design estimates. The blades are schematized into intransformable blades attached to the hub using hinges with a spring stiffness such that the rotating natural frequency of the model blade flap movement is equal to the real blade natural frequency.
Author (ESA)

**N86-18861#** Centre National d'Etudes Spatiales, Toulouse (France).
**LONG-DURATION FLIGHTS USING INFRARED MONTGOLFIERES**
P. MALATERRE *In* ESA The Seventh ESA Symposium on European Rocket and Balloon Programs and Related Research p 321-323 1985
Avail: NTIS HC A18/MF A01

A series of long-duration stratospheric balloon flights was carried out using infrared Montgolfiers. An IR Montgolfier is a hot-air balloon that captures solar radiation and IR Earth radiation as a heat source. A flight to study gravity waves lasted 52 days. Other uses include atmospheric data acquisition and radiation budget investigations. Author (ESA)

**N86-18894#** Air Force Environmental Technical Applications Center, Scott AFB, Ill.
**LIMITED SURFACE OBSERVATIONS CLIMATIC SUMMARY (LISOCS). PARTS A, C-F: BREMEN INTERNATIONAL, WEST GERMANY Data Summary Report, Sep. 1974 - Aug. 1984**
Jan. 1985 368 p
(AD-A159656; USAFETAC/DS-85/003) Avail: NTIS HC A16/MF A01 CSCL 04B

A statistical data summary of surface weather observation climatology for Bremen Intl., West Germany is presented. This summary is similiar to the Revised Uniform Summary of Surface Weather Observations (RUSSWO), but is based on data collected from limited-duty weather observing stations; i.e., those that take weather observations less than 24 hours a day, 7 days a week. The summary is in five parts: PART A, Weather Conditions and Atmospheric Phenomena; PART C, Surface Winds; PART D, Ceiling and Visibility; PART E, Psychrometric Summaries; and PART F, Pressure Summaries. Note that PART B, Precipitation, is omitted. See USAFETAC/TN-83/001 (AD-A132186), An Aid for Using the Revised Uniform Summary of Surface Weather Observations

(RUSSWOs), for complete descriptions of contents and instructions for use. Author (GRA)

**N86-18896#** Air Force Environmental Technical Applications Center, Scott AFB, Ill.
**REVISED UNIFORM SUMMARY OF SURFACE WEATHER OBSERVATIONS (RUSSWO). PARTS A-F: GENERAL BILLY MITCHELL FIELD, WISCONSIN Data Summary Report, Jan. 1974 - Dec. 1983**
Dec. 1984 425 p
(AD-A159658; USAFETAC/DS-84/038) Avail: NTIS HC A18/MF A01 CSCL 04B

A six-part statistical data summary of surface weather observation climatology for General Billy Mitchell Field, Wisconsin, consists of: PART A, Weather Conditions and Atmospheric Phenomena; PART B, Precipitation; PART C, Surface Winds; Part D, Ceiling and Visibility; PART E, Psychrometric Summaries; PART F, Pressure Summaries. See USAFETAC/TN-83/001 (AD-A132186), An Aid for Using the Revised Uniform Summary of Surface Weather Observations (RUSSWOs) for complete descriptions of contents and instructions for use. Author (GRA)

**N86-18900#** Air Force Environmental Technical Applications Center, Scott AFB, Ill.
**REVISED UNIFORM SUMMARY OF SURFACE WEATHER OBSERVATIONS (RUSSWO). PARTS A-F: AVIANO AB, ITALY Data Summary Report, Jan. 1974 - Dec. 1983**
Dec. 1984 383 p
(AD-A159662; USAFETAC/DS-84/037) Avail: NTIS HC A17/MF A01 CSCL 04B

A six-part statistical data summary of surface weather observation climatology for Aviano AB, Italy is presented. The summary consists of: PART A, Weather Conditions and Atmospheric Phenomena; PART B, Precipitation; PART C, Surface Winds; Part D, Ceiling and Visibility; PART E, Psychrometric Summaries; PART F, Pressure Summaries. See USAFETAC/TN-83/001 (AD-A132186), An Aid for Using the Revised Uniform Summary of Surface Weather Observations (RUSSWOs) for complete descriptions of contents and instructions for use. Author (GRA)

**N86-18902#** Oregon State Univ., Corvallis. Radiation Center.
**GIEBELSTADT AIN GERMANY (WEST). LIMITED SURFACE OBSERVATIONS CLIMATIC SUMMARY (LISOCS): PARTS A, C-F Data Summary Report, Aug. 1974 - Jul. 1984**
Feb. 1985 255 p
(AD-A159664; USAFETAC/DS-85/005) Avail: NTIS HC A12/MF A01 CSCL 04B

A statistical data summary of surface weather observation climatology for Giebelstadt Ain West, Germany is presented. This summary is similiar to the Revised Uniform Summary of Surface Weather Observations (RUSSWO), but is based on data collected from limited-duty weather observing stations; i.e., those that take weather observations less than 24 hours a day, 7 days a week. The summary is in five parts: PART A, Weather Conditions and Atmospheric Phenomena; PART C, Surface Winds; Part D, Ceiling and Visibility; PART E, Psychrometric Summaries; and Part F, Pressure Summaries. Note that PART B, Precipitation, is omitted. See USAFETAC/TN-83/001 (AD-A132186), An Aid for Using the Revised Uniform Summary of Surface Weather Observations (RUSSWOs), for complete descriptions of contents and instructions for use. Author (GRA)

**N86-18909#** Boeing Military Airplane Development, Seattle, Wash.
**ATMOSPHERIC ELECTRICITY HAZARDS THREAT ENVIRONMENT DEFINITION Interim Report, Aug. 1982 - Mar. 1984**
B. G. MELANDER and W. W. COOLEY Aug. 1985 155 p
(Contract F33615-82-C-3406)
(AD-A159739; AFWAL-TR-85-3052) Avail: NTIS HC A08/MF A01 CSCL 01B

This document provides definition of the atmospheric electricity threat environment as part of the Atmospheric Electricity Hazards Protection (AEHP) program. This issue contains an initial atmospheric electricity threat to be used for aircraft based on measurement of: (1) the lightning threat at the ground, and (2) the static electrification threat at altitude. The experimental basis for this threat is critically reviewed. Recommendations are made for future work in atmospheric electricity environments to refine and improve understanding of aircraft AEH environments. GRA

**N86-18910#** National Center for Atmospheric Research, Boulder, Colo.
**MICROBURST WIND SHEAR MODELS FROM THE JOINT AIRPORT WEATHER STUDIES (JAWS) Final Report**
W. FROST, H. P. CHANG, K. L. ELMORE, and J. MCCARTHY Jun. 1985 198 p
(Contract DTFA01-82-Y-10513)
(AD-A159758; DOT/FAA/PM-85/18) Avail: NTIS HC A09/MF A01 CSCL 04B

Multiple Doppler radar data collected during the Joint Airport Weather Studies (JAWS) Project is used to synthesize the three-dimensional wind in the region of a microburst. A six-degree-of-freedom numerical aircraft model having characteristics similar to Boeing 727 series aircraft is used to investigate jet transport aircraft response to microburst winds during simulated approaches and departures. Simple pilot control laws are used to adjust thrust, pitch, roll, and yaw so as to maintain given approach or departure parameters. Generally, when horizontal wind shear along the approach or departure path is .0001/s or greater, the model is unable to maintain the desired approach path and suffers a significant reduction in climb performance during a go-around or departure. Although the mean wind shear along a path gives a good qualitative measure of the wind shear threat to a jet transport, different paths with similar mean shears can yield markedly different results, as do the same paths with similar mean shears can yield markedly different results, as do the same paths through the microburst at different times, emphasizing the fine temporal and spatial scale of microburst winds. Finally, during the approximate 30 s period required for the aircraft to traverse the region of highest horizontal shear, time variations in the microburst wind field are shown to insignificantly affect the modelled flight path because the traverse period is a short time compared to the life time of a microburst. GRA

**N86-18912#** Air Weather Service, Scott AFB, Ill.
**CATALOG OF AIR WEATHER SERVICE TECHNICAL DOCUMENTS**
Jul. 1985 138 p
(AD-A159881; AD-E440298; AWS/TC-85/001) Avail: NTIS HC A07/MF A01 CSCL 04B

This catalog lists technical documents produced by or for the Air Weather Service and its subordinate units. Documents listed include technical reports, technical notes, data summaries, project reports, special studies, forecaster memos, follow-on training programs, microcomputer programs, and hand calculator programs. It includes availability data, ordering instructions, historical section. GRA

**N86-18921#** Air Force Geophysics Lab., Hanscom AFB, Mass.
**SOME MICROPHYSICAL PROCESSES AFFECTING AIRCRAFT ICING Final Scientific Report, 1 Oct. 1981 - 30 Sep. 1984**
H. J. SWEENEY and I. D. COHEN 8 May 1985 45 p
(AD-A160375; AFGL-TR-85-0100; AFGL-ERP-914) Avail: NTIS HC A03/MF A01 CSCL 04B

This report summarizes work done as part of the aircraft icing probabilities program. It contains a look at icing in layer-type clouds, a comparison of Particle Measuring System (PMS)2-D data from two flights. and a look at additional data obtained from researchers in the Federal Republic of Germany. The parameters measured in a warm and cold layer-type cloud near Peoria, IL are analyzed and compared. Liquid water content (LWC), cloud depth, particle diameter and particle concentration are compared. Variations of these parameters are compared. In mature clouds, where droplet sizes are approximately equal, the LWC is directly related to the number concentration. The icing rate, LWC and droplet size all increase as a function of height above cloud base. Synoptic patterns and PMS 2-D data obtained on two flights are compared. The first flight, made near Greensboro, NC was in an area of heavy precipitation. The large particles present produced very little icing. The other flight, near Flint, MI was in an area which was experiencing only spotty precipitation. The aircraft, however, experienced moderate icing. Data gathered on aircraft observations in the Federal Republic of Germany are examined. The data show that in strong icing situations, there are many particles with diameters of 10 to 20 microns. The results match those obtained by our research flights. GRA

**N86-18923#** Air Force Geophysics Lab., Hanscom AFB, Mass.
**IN-FLIGHT TURBULENCE DETECTION Final Scientific Report, 10 Oct. 1983 - 30 Sep. 1984**
A. R. BOHNE 8 Mar. 1985 61 p
(Contract DA PROJ. 667-0)
(AD-A160380; AFGL-TR-85-0049; AFGL-ERP-909) Avail: NTIS HC A04/MF A01 CSCL 04B

A limited set of radar and aircraft data acquired during the 1981 and 1982 Joint Agency Turbulence Experiment are used to compare incoherent and coherent radar methods for atmospheric turbulence severity estimation. Time series of ground-based radar in-phase and quadrature signal return data are processed by Doppler (Fast Fourier Tranform) and incoherent (R-meter with and without noise correction) methods to determine Doppler spectrum variance. These variance data serve as input to a turbulence algorithm to derive estimates of turbulence severity. These estimates are then compared with in-situ aircraft measurements. Results show the order of preference for the radar methods is Doppler, R-meter with noise correction, and R-meter without noise correction. The R-meter without noise correction method must be considered unreliable since it results in large overestimates of turbulence severity when the signal to noise ratio is less than about 12 dB. The R-meter with noise correction method generally duplicates well the results derived from Doppler analysis and may be considered a reasonable alternative when Doppler capability is not available. GRA

**N86-18924#** Air Force Geophysics Lab., Hanscom AFB, Mass.
**JOINT AGENCY TURBULENCE EXPERIMENT Final Report, 1 Oct. 1981 - 30 Sep. 1984**
A. R. BOHNE 21 Jan. 1985 218 p
(Contract AF PROJ. 6670)
(AD-A160420; AFGL-TR-85-0012; AFGL-ERP-905) Avail: NTIS HC A10/MF A01 CSCL 17I

Doppler radar and aircraft data acquired during the 1981 and 1982 observation seasons are discussed. Time histories of Doppler radar mean velocity and spectrum variance data acquired while tracking an instrumented aircraft during 34 thunderstorm penetrations are presented. Time histories and analysis of turbulence severity, as determined from these radar and aircraft data, are also presented. Whereas use of radar mean velocity in structure function analysis results in underestimation of the actual turbulence severity, radar methods based upon Doppler spectrum variance successfully detect regions of turbulence hazardous to aircraft. The variance-based method, employing a modeled turbulence energy spectrum with a maximum finite eddy size, is found most effective when the turbulence outer scale lies in the range of 1 to 4 km. Classification of turbulence severity as light, moderate, heavy, or severe with a single outer scale value was unreliable. However, classification into composite severity classes, where a composite class combined two or more individual severity classes, was found to be a successful approach for locating hazardous and nonhazardous turbulence regions. Data also show Doppler spectrum variance to be poorly correlated with shear of the radial wind. This shear, resulting from nonturbulence storm structure generally contributed less than 10% of the turbulence contribution to Doppler spectrum variance and could generally be neglected when estimating turbulence severity. GRA

**N86-18933#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abt. Meteorologische Fernerkundung.
**CALCULATION OF ICE ACCRETION ON CYLINDRICAL RODS ACCORDING TO BAIN'S MODEL, AND COMPARISON WITH EXPERIMENTAL RESULTS**
W. FUCHS (Geophysikalische Beratungsstelle Roth, West Germany), K. P. SCHICKEL, J. KALUZA (Geophysikalische Beratungsstelle, Cochem, West Germany), and K. UWIRA (Bundesamt fuer Wehrtechnik und Beschaffung, Landsberg/Lech, West Germany) Jul. 1985 81 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-970)
(DFVLR-FB-85-46; ISSN-0171-1342) Avail: NTIS HC A05/MF A01; DFVLR, Cologne DM 25.50

Bain's model for the calculation of ice accretion rates was compared with meteorological flight data. The Bain model for the determination of the ice accretion rate on cylindrical rods is extended to the calculation of the accretion shape and velocity in pure water clouds. Ice accretion is measured on an aircraft during flights in stratus clouds. By taking into account the energy balance estimate of Ludlam for the calculation of an upper bound on the spontaneously freezing supercooled liquid water content (LWC), good agreement between the calculated and measured ice accretion is obtained. The effect of higher LWC's on the ice accretion is not proportional, as theory shows. Author (ESA)

**N86-19808#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
**WIND SHEAR INVESTIGATION PROGRAM AT THE NLR**
H. HAVERDINGS 23 Mar. 1984 52 p refs In DUTCH; ENGLISH summary Presented at Aeronautical Symposium, Delft, Netherlands, 13 Apr. 1984
(NLR-MP-84027-U; B8571447) Avail: NTIS HC A04/MF A01

Wind shear statistics were collected from wide-body aircraft equipped with an airborne integrated data acquisition system during 9000 approaches and landings. In the resulting time dependent wind profiles, wind shear occurrences were analyzed, using a statistical discrete gust method. Flight simulation studies of F-28 aircraft landings for 8 wind profiles with different wind shear types were performed to evaluate 2 wind shear detectors. During the simulation, effort ratings of three pilots for air speed control and tracking the glide path were established. The indication of flight energy deviation is preferred above indication of this magnitude expressed in change of time. Ground and on-board indicators, including apparatus using predictive remote sensing techniques were surveyed. Author (ESA)

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# LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-23724**
**COCKPIT AUTOMATION TECHNOLOGY**
A. J. ARETZ (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1984, p. 487-491.

This paper presents a prototype methodology conceived by the United States Air Force to establish a baseline approach in the development of a new human factors crew station design methodology for emerging weapon systems. The goal of the project is to develop a structured human factors design methodology that can be used by designers to assess emerging technologies and relate them to system requirements and human performance characteristics so that the features of the resulting designs satisfy specific operational mission objectives. Author

**A86-23738**
**CONCEPT FLYING - A METHOD FOR DERIVING UNIQUE SYSTEM REQUIREMENTS**
J. C. SIMONS and S. B. HOTTMAN (Systems Research Laboratories, Inc., Dayton, OH) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1984, p. 825-828. refs

Simons (1974) discussed an approach to achieving concept breakthroughs by inserting intuitive researchers in loosely structured, scaled-down situations. The approach involves the observation of the pilot when he is interacting in a loosely constrained operational environment. The considered approach, called 'concept flying', represents a technique for the development of new systems designs. Today the main shortfall of concept flying techniques is that they are seldom used. The present paper provides successful concept-flight programs, and new proposals for using concept flying in a study of concepts which are beyond the capabilities of current aircraft. G.R.

**A86-25651**
**NOISE LEVELS IN COCKPITS OF AIRCRAFT DURING NORMAL CRUISE AND CONSIDERATIONS OF AUDITORY RISK**
D. C. GASAWAY (Cabot Corp., E-A-R Div., Indianapolis, IN) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, Feb. 1986, p. 103-112. refs

Noise data, including A-levels and C-minus-A values, are summarized for exposures associated with normal cruise flight in 13 groups of 593 aircraft; means and standard deviations are reported; degrees of auditory risk using OSHA-1983 criterion are presented; and at-the-ear protected and unprotected exposures are revealed. Mean A-levels were 95.0 for 528 fixed-wing; 100.9 for 65 rotary-wing; and 95.7 for all 593 aircraft. Of 13 subgroups, the lowest mean A-level (85.5) was exhibited in the cockpits of tail-mounted turbojet/fan-powered aircraft, and the highest (105.0) was found in both reciprocating and turbine-powered twin-rotor helicopters. All means A-levels exceeded the OSHA damage-risk criterion for 8 h/d exposures. At-the-ear exposures while wearing hearing protection are presented. Results clearly illustrate the potential for auditory damage of unprotected aircrews. Hearing protection must be considered to effectively control routinely encountered exposures. The material and illustrations resulting from this study will help health and safety monitors during indoctrination and counseling of aircrews concerning the need to protect their hearing against noise exposures during normal and routine flight operations. Author

**A86-25652**
**EFFECT OF SEAT CUSHIONS OF HUMAN RESPONE TO +GZ IMPACT**
B. F. HEARON and J. W. BRINKLEY (USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, OH) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, Feb. 1986, p. 113-121. refs
(Contract F33615-83-C-0500)

Several ejection seat cushions are evaluated based on human response to vertical impact acceleration. The cushions consist of: (1) one layer of 5.1 cm thick low-density conventional polyurethane foam and a second layer of 1.3 cm thick high-density plastic foam (F-111 cushion); (2) a layer of 1 cm thick sheet foam polyethylene, 1.3 cm Temper foam, and 0.6 cm thick space fabric (ACES II cushions); and (3) 5.1 cm thick rate-dependent slow-recovery polyurethane foam. Vertical impact tests were performed on 25 subjects of 26.1 + or - 3.4 years, weighing 79.1 + or - 9.0 kg, and 178 + or - 7.1 cm tall; the test conditions and equipment are described. The carriage acceleration and velocity, seat loads, and head and chest acceleration are measured and compared. The data reveal that the F-111 and ACES II cushions have higher seat loads and head and chest accelerations than the rate-dependent polyurethane foam cushions; it is concluded that the rate-dependent cushions provided greater impact protection than current operational cushions. I.F.

**A86-26002**
**FLIGHT DECK AUTOMATION DECISIONS**
E. F. WEENER (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 3-8. refs
(SAE PAPER 841471)

Effective man-machine interface design for an airplane flight deck depends strongly on providing apppropriate levels of control capability for use by the flight crew. The range of control options available to the airplane system designer extends from manual through partially automatic to full automatic. Selection of appropriate types and levels of automation for each new airplane is a complex task. It involves understanding the capabilities and limitations of the human operator, airplane operational and functional considerations, as well as concerns for cost and available technology. Recent airplanes have demonstrated the practicality of providing different levels of automation which can be applied by the flight crew under different circumstances. This trend expands the options available to the flight crew in coping with the changing operational environment. It also allows the flight crew to participate directly in the choice of when and how to apply automation. This paper describes the various automation factors which are considered in the process of developing a design. Author

**A86-26003**
**FLIGHT DECK DESIGN METHODOLOGY USING COMPUTERIZED ANTHROPOMETRIC MODELS**
G. STONE and H. MCCAULEY (Douglas Aircraft Co., Long Beach, CA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 9-16. refs
(SAE PAPER 841472)

A new 'inside out' flight deck design methodology has been developed, in which the flight crew member is the logical starting point. Several computer models that simulate varying pilot sizes, proportions, reach, and vision capabilities are created and utilized to generate the required 'envelopes' of vision, reach, and motion for the entire range of the pilot population. These envelopes are then employed to define the internal geometric relationships of the flight deck and its components. The methodology is described, including discussions of the aspects of defining the user population, generation of crew sample, creating a three-dimensional operator model, determining functional envelopes, and component integration. Design diagrams are included. I.S.

**A86-26004**

### AI APPLICATIONS TO MILITARY PILOT DECISION AIDING - A PERSPECTIVE ON TRANSITION

W. G. JAMES (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 19-24.
(SAE PAPER 841533)

The process of transition of the Pilot Decision Aiding AI technology to operational application is discussed in the framework of various R&D programs. The experience of implementing the 'intent-driven' cockpit technology in a Coast Guard helicopter and in simulation and flight test programs is described. A priority list of the subsystems and activities sufficiently mature for early automation and decision aiding is given, and the three consecutive steps to be taken for the transition ('Imitate', 'Embellish', and 'Fully Exploit') are explained. The importance of an airborne development program that precedes the flight evaluation program is emphasized. I.S.

**A86-26005**

### AUTOMATION IN THE COCKPIT - WHO'S IN CHARGE?

R. W. MOSS, J. M. REISING, and N. R. HUDSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 25-29. refs
(SAE PAPER 841534)

This paper discusses levels of automation and decision making and arrives at an overall design philosophy for allocating tasks to the pilot and the computer. In order to produce a levels of automation matrix three categories of pilot-computer interface (pilot only, blended, and computer only) and three types of goals, (mission, functional and task), are identified. These two dimensions are then used to create a matrix which can be employed as a means of comparing automated systems. The options that the matrix produces are discussed and examples given. The overall design philosophy is to have the mission goals accomplished in a blended manner with both the pilot and computer contributing. Lower level goals are handled exclusively by the computer. The reasoning for this philosophy is to allow the pilot to operate in a rule-based environment so that he can optimally cope with the greatly increased amounts of information he will face in future missions. Author

**A86-26009**

### EFFECT OF VIBRATION ON THE READABILITY OF COLOR CRT DISPLAYS

L. IVEY (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 53-59. refs
(SAE PAPER 841466)

The readability of symbols on a color CRT display in a vibrational environment equivalent to low-level flights was rated by eight aircraft personnel subjects undergoing tests in a Sixmode motion simulator. The differences in the values of the chrominance and luminance between static and vibrational conditions were determined. In addition, the impact of wearing protective PLZT goggles was evaluated. The comfortable viewing zone for the normal (non-PLZT) case was between 2.5 and 6.5 Hz, whereas the zone with PLZT was between 3 and 6.5 Hz. The colors and symbol changes caused by the applied vibration were acceptable, indicating the stability of the Sperry CRT shadow mask. The legibility data indicate that in a vibration environment, a minimum symbol size of greater than 0.12 in. is necessary. The digital update rate change should be between 3 and 5 Hz for the most comfortable viewing and the least errors. I.S.

**A86-26016**

### A REVIEW OF PILOT WORKLOAD MEASUREMENT TECHNIQUES USED ON THE A-10 SINGLE SEAT NIGHT ATTACK TEST PROGRAM

C. D. CRITES (USAF, Human Factors Branch, Edwards AFB, CA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 107-112.
(SAE PAPER 841492)

A three-phase flight test program to evaluate the A-10 Single Seat Night Attack (SSNA) aircraft was conducted at the Air Force Flight Test Center (AFFTC), Edwards AFB, CA. An important objective of the SSNA testing was to assess, and where possible, measure pilot workload. The techniques utilized during the test program to quantify workload were: an objective measurement of task performance, control activity, and physiological status data, and the Subjective Workload Assessment Technique (SWAT). The use of objective techniques represented the first application in a flight test environment and an initial attempt to validate their use as work-load metrics. Both objective and subjective methods were of significant value, but both techniques had limitations and shortfalls. Lessons learned affecting the application of the techniques to on-going and future flight test programs are described. Author

**A86-26018**

### ADVANCED FIGHTER TECHNOLOGY INTEGRATION (AFTI) F-16 - THE PILOT INTERFACE

D. R. MCMONAGLE (USAF, Flight Test Center, Edwards AFB, CA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 121-125.
(SAE PAPER 841633)

The aspects of the pilot-vehicle interphase in the two first phases of the Advanced Fighter Technology Integration (AFTI)/F-16 Program, which was designed to develop and demonstrate technologies and alternatives for future fighter aircraft design, are discussed. The results of the first AFTI phase, the Digital Flight Control System, indicated the need for multiple flight control mode capability in future multirole fighter aircraft. The second phase of the Program, the Automated Maneuvering Attack System, which began in July 1984, involves the development and evaluation of improved sensors, integrated fire and flight control for automated maneuvering weapon delivery, and enhancements in pilot-vehicle interface. I.S.

**A86-26019*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### EFFECTS OF DIGITAL ALTIMETRY ON PILOT WORKLOAD

R. L. HARRIS, SR. (NASA, Langley Research Center, Hampton, VA) and B. J. GLOVER (Kentron International, Inc., Hampton, VA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 131-136. Previously announced in STAR as N86-13892.
(SAE PAPER 841489)

A series of VOR-DME instrument landing approaches was flown in the DC-9 full-workload simulator to compare pilot performance, scan behavior, and workload when using a computer-drum-pointer altimeter (CDPA) and a digital altimeter (DA). Six pilots executed two sets of instrument landing approaches, with a CDPA on one set and a DA on the other set. Pilot scanning parameters, flight performance, and subjective opinion data were evaluated. It is found that the processes of gathering information from the CDPA and the DA are different. The DA requires a higher mental workload than the CDPA for a VOR-DME type landing approach. Mental processing of altitude information after transitioning back to the attitude indicator is more evident with the DA than with the CDPA. E.A.K.

**A86-26022**

### WINGING IT IN THE 1980'S - WHY GUIDELINES ARE NEEDED FOR COCKPIT AUTOMATION

M. R. HOAGLAND (Air Line Pilots Association, International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 155-162. refs
(SAE PAPER 841634)

There have been many reasons for the introduction of automation into the cockpit of the modern airliner. In some cases the forces driving technology have caused the design of automated systems which compromise the ability of the pilot to fulfill his responsibilities for the safety of the airplane under his command. This paper examines how these forces can lead to unnecessary cockpit automation, and discusses what must be done to avoid the introduction of automated systems which have the effect of removing the human operator from the information and control processes. Author

**A86-26023**

### SITUATION VERSUS COMMAND

J. G. OLIVER (Air Line Pilots Association, International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 163-165.
(SAE PAPER 841638)

Two types of flight information are provided to pilots, situational and command. Situation information tells the pilot the state of the aircraft and its flight path while command information tells the pilot what to do and is not related to any given situation. This paper discusses why it is extremely important for the pilot to be provided with appropriate and adequate situation information in all aircraft but especially in modern highly-automated aircraft. Author

**A86-26024**

### THE DECISION TO FLY

A. F. ZELLER IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 169-176.
(SAE PAPER 841613)

The decision to fly and the capacity to carry a flight to a successful termination involves a wide spectrum of background determinants. These range from considerations of the pilot as a physical being with specific potentials and limitations of body structure, mental ability and emotional capacities to the adequacy of learning related to a specific performance and the character and condition of the aircraft. Specific factors relevant to each of these categories is discussed including the psycho-social, physiological and pathological. Crucial to success is the pilot's self-critical judgement. There is a necessary tension between the ongoing activity of carrying out a positive decision to fly and the requirements for continual assessment of the situation. Author

**A86-26028**

### U.S. ARMY HELICOPTER VOICE TECHNOLOGY APPLICATIONS

F. J. MALKIN (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 207-211. refs
(SAE PAPER 841609)

Voice technology provides a potential for alleviating the extremely high visual and manual workload of Army helicopter pilots. Before voice technology can be successfully employed in the cockpit, there are many human factors issues that must be resolved. This paper describes the approach used to identify potential applications of voice technology in an Army helicopter and the emulation of a voice interactive Doppler navigation set. Author

**A86-26030*** Psycho-Linguistic Research Associates, Menlo Park, Calif.

### COMPARISON OF VOICE TYPES FOR HELICOPTER VOICE WARNING SYSTEMS

C. A. SIMPSON, K. MARCHIONDA-FROST, and T. NAVARRO (Psycho-Linguistic Research Associates, Menlo Park, CA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 217-224. Army-supported research. refs
(Contract NAS2-11341)
(SAE PAPER 841611)

Three related studies were conducted to compare different types of human voice warnings. In the first study, a comparison of three LPC-encoded voices, human female, human male, and phoneme-synthesized, by the criteria of pilot flight task performance showed no differences due to the voice type. In the second study, pilots' preferences were investigated, by comparing preference for direct synthesized speech to the LPC-encoded human female speech and to LPC-encoded synthesized speech. Most pilots were found to prefer direct synthesized speech over both LPC-encoded human female speech and the LPC-encoded synthesized speech. In the third study, phonetically balanced (PB) words heard in simulated helicopter noise were used to compare the intelligibility of direct synthesized and LPC-encoded phoneme-synthesized speech types. PB word intelligibility was found to be better for direct synthesized speech than for the LPC-encodes synthesized speech. I.S.

**A86-26031**

### ADVANCED TECHNOLOGY - NEW FIXES OR NEW PROBLEMS?

C. A. SIMPSON (Psycho-Linguistic Research Associates, Menlo Park, CA) IN: Aerospace Behavioral Engineering Technology Conference, 3rd, Long Beach, CA, October 15-18, 1984, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 225-236. refs

The principles of application of voice technology to cockpit control and display systems, the advantages of its use and the pitfalls of its misuse or overuse are discussed. The omnidirectionality and the sequential nature of speech imply the general requirements of short sentences, the minimal number of multiple messages, and avoidance of concurrent messages in the use of voice for both display and command purposes. To be of an advantage to the pilot, the use of voice displays must be limited to time-critical flight information, and the use of voice control must be limited to time-critical operations, both at the time when the pilot is visually or manually occupied to the extent that the voice display/command will reduce his workload. Especially important will be an integrated design of all voice controls and displays in order to avoid overloading the pilot with multiple messages and required control inputs, in a transmission mode that is essentially a single-channel system. I.S.

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# MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-23263**
**FLIGHT TEST DATA ACQUISITION AND PROCESSING SYSTEM**
B. J. FISTER (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 12-1 to 12-10.

The development of a modern and effective data acquisition and processing system for flight testing commercial aircraft engines is discussed. The specifications and required accuracy of the system are presented, and the various aspects of the data acquisition system are examined, including the input, block design, block temperature determination, analog multiplexer, pressure system, calibration, transducers, frequency measurement, and output. A system block description is given, and the ground station and calibration are described. The system's two main operating modes for acquiring data, a steady state mode and a transient mode, are addressed. The software data flow is shown and described, and present operating experience is reported. C.D.

**A86-23264**
**A STUDY OF STATE OF THE ART COMPUTER GRAPHICS SYSTEMS FOR FLIGHT SAFETY MONITORING**
D. J. MALONE (Computer Sciences Corp., Systems Div., Lompoc, CA) and M. SHRADER-FRECHETTE (Florida, University, Gainesville) IN: Society of Flight Test Engineers, Annual Symposium, 15th, St. Louis, MO, August 12-16, 1984, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1984, p. 13-1 to 13-14. refs

The state of the art in high-speeds, high-resolution, computer-driven, color-graphic display systems suitable for the growth of a currently in-place but obsolescent systems is studied. Potential deficiencies of present systems in the areas of quality of the display image and saturation of the host or display processors are discussed. Currently available graphic display system technologies are examined, including display screen technologies, display controllers, and graphics processors. Needed display features are determined, readily available components which have the required features are identified, and recent technological advances are extrapolated in order to identify future developments. C.D.

**A86-23343**
**DYNAMIC SYSTEMS: MODELLING AND CONTROL; PROCEEDINGS OF THE WINTER ANNUAL MEETING, MIAMI BEACH, FL, NOVEMBER 17-22, 1985**
M. DONATH, ED. (Minnesota, University, Minneapolis) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers (Dynamic Systems and Control Symposia Series. DSC Volume 1), 1985, 351 p. .

Various papers on system dynamics and its control are presented. The general topics discussed include: adaptive control, systems modelling and control, fluid control systems, system identification theory and its applications, strategies for control system design, dynamics and control of thermofluid design, and vehicle system dynamics. Some of the individual papers address: nonlinear control of a distributed system, stability study of vortex amplifier distributed circuits, stable discrete-time adaptive observer applied to multivariable aircraft, reduction of discrete multivariable systems by stochastic approximations, parameter identification by robot control, and decoupling in distributed control system through error compensation. C.D.

**A86-23581**
**OPTIMAL CONTROL OF INTEGRAL-FUNCTIONAL EQUATIONS [OB OPTIMAL'NOM UPRAVLENII INTEGRAL'NO-FUNKTSIONAL'NYMI URAVNENIIAMI]**
L. E. SHAIKHET Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 49, Nov.-Dec. 1985, p. 923-934. In Russian. refs

The optimal control of a stochastic integral-functional equation of neutral type with an integral quality functional is examined. The necessary condition of control optimality is established. An explicit form of optimal control is obtained in the case of a linear quadratic problem. B.J.

**A86-23708**
**A STUDY OF PROGRAMMABLE SWITCH SYMBOLOGY**
J. S. HAWKINS, J. M. REISING, B. K. WOODSON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and S. J. BERTLING (U.S. Air Force Academy, Colorado Springs, CO) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1984, p. 118-122. refs

A multifunction switch is one way to solve the diminishing real estate problem in the modern cockpit. This study looked at pictorial coding of such a switch. Twelve different symbols were used, each with three levels of complexity and two levels of polarity. An error rate count was taken for subjects under both a naive and learned 50 millisecond exposure condition. This study demonstrated that there were three classes of symbols. These were: intuitive to the naive subject, intuitive to a learned subject, and nonintuitive, even to a learned subject. Complexity levels had a significant effect in only three of the twelve symbols. Polarity differences also had a significant effect in only three of the twelve symbols, although they were a different three. The overall conclusion is that the majority of symbols were intuitive after learning and robust to changes in complexity and polarity. Author

**A86-24586**
**OPTIMIZATION OF STEPPED INPUT SIGNALS IN THE FREQUENCY DOMAIN FOR PARAMETRIC IDENTIFICATION [OPTIMIERUNG STUFENFOERMIGER EINGANGSSIGNALE IM FREQUENZBEREICH FUER DIE PARAMETERIDENTIFIZIERUNG]**
K.-O. PROSKAWETZ (Braunschweig, Technische Universitaet, Brunswick, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, Nov.-Dec. 1985, p. 362-370. In German. refs

For parameter determination in dynamic systems, optimized input signals with energy density spectra of desired shape and energy density level are required. Mathematical relationships for optimizing stepped input signals with respect to their energy density spectra are presented, and the influence of control parameters is discussed. Some optimized, stepped input signals and their energy density spectra are presented along with their application to parameter estimation in a simulated aircraft model. C.D.

**A86-25035*** California Univ., Davis.
**AUTOMATION EFFECTS IN A MULTILOOP MANUAL CONTROL SYSTEM**
R. A. HESS and B. D. MCNALLY (California, University, Davis) IEEE Transactions on Systems, Man, and Cybernetics (ISSN 0018-9472), vol. SMC-16, Jan.-Feb. 1986, p. 111-121. refs
(Contract NAG2-221)

An experimental and analytical study was undertaken to investigate human interaction with a simple multiloop manual control system in which the human's activity was systematically varied by changing the level of automation. The system simulated was the longitudinal dynamics of a hovering helicopter. The automation-systems-stabilized vehicle responses from attitude to velocity to position and also provided for display automation in the form of a flight director. The control-loop structure resulting from the task definition can be considered a simple stereotype of a hierarchical control system. The experimental study was complemented by an analytical modeling effort which utilized simple crossover models of the human operator. It was shown that such models can be extended to the description of multiloop tasks involving preview and precognitive human operator behavior. The existence of time optimal manual control behavior was established for these tasks and the role which internal models may play in establishing human-machine performance was discussed. Author

**A86-26118#**
**THE DEVELOPMENT AND APPLICATION OF FINITE ELEMENT STRESS ANALYSIS TECHNIQUES AT WESTLAND HELICOPTERS LTD**
M. L. W. SALZER and P. C. WOOD (Westland, PLC, Helicopter and Hovercraft Group, Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 22 p.

This paper discusses the role of the finite element method in the design-development cycle. No attempt is made to give a theoretical background but rather to outline the technique, method of implementation and areas of application. In particular the pre- and post-processing software package WISDOM is examined and the steps involved in performing a finite element statics analysis. It is envisaged that with more powerful computers and the acceptance of CAD solid modelling in design, that the time required to perform a finite element analysis will be reduced even further. Some of the improvements that are required to achieve this time reduction are also discussed. Author

**A86-26166#**
**DEVELOPMENT TESTING OF INTEGRATED AVIONICS SYSTEMS USING DYNAMIC ENVIRONMENT SIMULATION**
P. L. SHILLITO (Westland Helicopters, Ltd., Yeovil, England) Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984, Paper. 21 p. refs

The evolution of sophisticated integrated avionics packages and their incorporation into civil and military helicopters has caused and will continue to cause significant perturbations to avionics and airframe manufacturers' integration plans. A coherent testing philosophy is discussed which co-ordinates avionic system design with its supporting development and validation tools. Highlighted is the use of inherent system performance data to maintain, system integrity during validation of the developed system core whilst permitting full test automation. Facilities developed for dynamic simulation and performance assessment and presentation are described. These techniques are shown to reduce costs, improve effectiveness, and provide a high demonstrable level of confidence in the resultant integrated system. Author

**N86-19008*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**PARTITIONING AND PACKING MATHEMATICAL SIMULATION MODELS FOR CALCULATION ON PARALLEL COMPUTERS**
D. J. ARPASI and E. J. MILNER 1986 38 p refs Prepared for Presentation at the 1986 International Conference on Parallel Processing, St. Charles, Ill., 19-22 Aug. 1986; sponsored by Pennsylvania State Univ. and IEEE Computer Society
(NASA-TM-87170; E-2808; NAS 1.15:87170) Avail: NTIS HC A03/MF A01 CSCL 09B

The development of multiprocessor simulations from a serial set of ordinary differential equations describing a physical system is described. Degrees of parallelism (i.e., coupling between the equations) and their impact on parallel processing are discussed. The problem of identifying computational parallelism within sets of closely coupled equations that require the exchange of current values of variables is described. A technique is presented for identifying this parallelism and for partitioning the equations for parallel solution on a multiprocessor. An algorithm which packs the equations into a minimum number of processors is also described. The results of the packing algorithm when applied to a turbojet engine model are presented in terms of processor utilization. Author

**N86-19045#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**AN INTRODUCTION TO THE APPLICATION OF COMPUTER AIDED DESIGN (CAD) TO THE PREDESIGN OF AIRCRAFT AND THE DESIGN OF AIRCRAFT STRUCTURES AT THE AEROSPACE SECTION [EEN INTRODUKTIE TOT DE TOEPASSING VAN CAD IN HET VOORONTWERPEN VAN VLIEGTUIGEN EN HET ONTWERPEN VAN VLIEGTUIGKONSTRUKTIES AAN DE AFDELING DER LUCHTVAART- EN RUIMTEVAARTTECHNIEK]**
C. BIL and A. ROTHWELL Mar. 1984 31 p refs In DUTCH
(VTH-M-512) Avail: NTIS HC A03/MF A01

Equipment and software of a CAD plant are described and research in aircraft and aircraft structures design is surveyed. Possibilities to integrate an aircraft design and analysis system, the graphical design system MEDUSA, and GIFTS, a program generating calculation models from drawings of existing structures, are outlined. The aim is to create a pilot design system comparable with industrial CAD activities in the preconceptual phase.
Author (ESA)

**N86-19634#** Royal Signals and Radar Establishment, Malvern (England). Integrated Air Defence Systems Div.
**APPLICATIONS OF EXPERT SYSTEMS**
P. R. WETHERALL *In* AGARD Artificial Intelligence and Robotics 17 p Sep. 1985 refs
Avail: NTIS HC A07/MF A01

An Expert System contains a knowledge base, an inference engine, an explanation system, a model of the real world and a man machine interface. The types of reasoning include interpretation, monitoring, prediction and design, together with specializations of these, such as diagnosis and planning, and aggregations, such as debugging, instruction and control. A range of possible applications are described to illustrate these general tasks. The nature of the knowledge available, and some implementation problems, are identified. The applications include examples in the area of tactical decision aids, specifically sensor data interpretation, data fusion, threat assessment and resource allocation. Other topics include cockpit environments and intelligent tutoring. Finally, some of the problems that limit the immediate widespread adoption of the technology are discussed. Author

**N86-19968*#** Computer Sciences Corp., Silver Spring, Md.
**AN APPROACH TO DEVELOPING SPECIFICATION MEASURES**
W. W. AGRESTI *In* NASA. Goddard Space Flight Center Proceedings of the Ninth Annual Software Engineering Workshop p 14-41 Nov. 1984 refs
Avail: NTIS HC A16/MF A01

An approach to developing specification measures is described. A key feature of the approach is the introduction of a new requirements representation, the Composite Specification Model (CSM). Results are reported from an experiment in which the requirements for a real system are recast using the CSM. Specification measures are then extracted from the CSM representation of the system. Author

**N86-20006#** Air Force Armament Lab., Eglin AFB, Fla.
**MELLIN-FOURIER CORRELATION Final Technical Report, Jun. 1982 - Jan. 1984**
E. C. FRIDAY Aug. 1985 53 p
(Contract AF PROJ. 230-5)
(AD-A159685; AD-E801193; AFATL-TR-85-53) Avail: NTIS HC A04/MF A01 CSCL 05H

This program evaluates the success of a pattern recognition system which attempts to recognize an object even though the object differs in size and orientation from the object used as a reference. The criteria for recognition were the peak value and shape of the cross correlation function calculated in two dimensions. The cross correlation was performed using Fourier transform techniques to judge the utility of implementing the system using many standards optical components. Size, or scale, invariance was achieved using a logarithmic sampling technique (the Mellin transform), and variations on traditional sampling methods were shown to extend the scale invariance predicted by various researchers. The utility of the sampling techniques developed was proven using images acquired from infrared sensors carried aboard helicopters. Limits of practical scale invariance were explored and system design approaches were suggested from the results of numerical experiments carried out in computer simulations. GRA

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# PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-23134*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AIRFOIL TIP VORTEX FORMATION NOISE**
T. F. BROOKS and M. A. MARCOLINI (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, Feb. 1986, p. 246-252. Previously cited in issue 01, p. 73, Accession no. A85-10859. refs

**A86-23576**
**LIAPUNOV FUNCTION FOR STUDYING THE STABILITY IN THE WHOLE OF NONLINEAR SYSTEMS [FUNKTSII LIAPUNOVA DLIA ISSLEDOVANIIA USTOICHIVOSTI V TSELOM NELINEINYKH SISTEM]**
A. B. AMINOV and T. K. SIRAZETDINOV Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 49, Nov.-Dec. 1985, p. 883-893. In Russian. refs

Sufficient conditions are obtained for the sign-determinacy of a sum of polylinear forms. These sums are used to form Liapunov functions which are employed to derive sufficient conditions for the asymptotic stability in the whole of the unperturbed motion of nonlinear systems. The perturbed motions are described by a set of ordinary differential equations with a right part in the form of a sum of homogeneous polynomials. The proposed approach is applied to the analysis of the longitudinal stability of an aircraft with allowance for the nonlinearity of the aerodynamic coefficients and nonlinear relations between the angle of attack and the pitch angle. B.J.

**A86-23674**
**LONGITUDINAL POTENTIAL DISTRIBUTION IN A JET OF AN IONIZED GAS [PRODOL'NOE RASPREDELENIE POTENTSIALA V REAKTIVNOI STRUE IONIZOVANNOGO GAZA]**
N. M. PISAREV, IU. P. STAVROV, and V. I. TAMBOVTSEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1985, p. 99, 100. In Russian.

The effect of longitudinal potential distribution in stationary jets of an ionized gas, such as those produced by jet aircraft, is investigated experimentally for the case where a jet of an ionized gas issues from an axisymmetric conical nozzle into a space flooded with a neutral gas. An expression is obtained for the longitudinal potential distribution for the main section of a jet relative to its source for quasi-neutral conditions. The validity of the expression is verified experimentally for a jet engine with a thrust of 230 N and a discharge velocity of 1800 m/s. V.L.

**A86-25217#**
**RESEARCH ON SONIC INLET**
R. SASAKI, Y. KOHAYAGAWA, K. HIRAOKA, and T. WATANABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 378, 1985, p. 420-432. In Japanese, with abstract in English.

In recent aircraft with high by-pass ratio engines, the major noise source is the forward propagating fan noise from the engine inlet. Reported here is the investigation of the sonic inlet, which drastically reduces the abovementioned forward propagating fan noise. Model sonic inlets of both contracting wall type and translating centerbody type were designed by a newly developed analytical method based on flux analysis, and tested aerodynamically and acoustically. Criteria for boundary layer separation, total pressure recovery characteristics, and crosswind characteristics of a sonic inlet were obtained, and a model sonic inlet of the contracting wall type showed 21 PNdB noise reduction in model engine noise tests. Comparison between the analytical and experimental results proved the usefulness of the newly developed design method. Author

**N86-19123** New South Wales Univ., Kensington (Australia).
**HIGH VELOCITY GAS JET NOISE CONTROL Abstract Only**
A. DAY 1985 3 p
Avail: Issuing Activity

The physics of jet noise generation, and some of the principal applications and methods of jet noise control are described. Jet noise generation due to the nozzle size, discharge velocity, gas density, jet shape, etc., is well documented by scientific literature, complete with mathematical formulae for noise level prediction. Worked examples are provided. G.L.C.

**N86-19125*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**LABORATORY EXPERIMENTS ON ACTIVE SUPPRESSION OF ADVANCED TURBOPROP NOISE**
J. H. DITTMAR Dec. 1985 18 p refs
(NASA-TM-87129; E-2740; NAS 1.15:87129) Avail: NTIS HC A02/MF A01 CSCL 20A

The noise generated by supersonic tip speed propellers may be a cabin environment problem for future propeller-driven airplanes. Active suppression from speakers inside the airplane cabin has been proposed for canceling out this noise. The potential of active suppression of advanced turboprop noise was tested by using speakers in a rectangular duct. Experiments were first performed with sine wave signals. The results compared well with the ideal cancellation curve of noise as a function of phase angle. Recorded noise signals from subsonic and supersonic tip speed propellers were than used in the duct to deterthe potential for canceling their noise. The subsonic propeller data showed significant cancellations but less than those obtained with the sine wave. The blade-passing-tone cancellation curve for the supersonic propeller was very similar to the subsonic curve, indicating that it is potentially just as easy to cancel supersonic as subsonic propeller blade-passing-tone noise. Propeller duct data from a recorded propeller source and spatial data taken on a propeller-drive airplane showed generally good agreement when compared versus phase angle. This agreement, combined with the similarity of the subsonic and supersonic duct propeller data, indicates that the area of cancellation for advanced supersonic propellers will be similar to that measured on the airplane. Since the area of cancellation on the airplane was small, a method for improving the active noise suppression by using outside speakers is discussed. Author

**N86-19127#** Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.
**FLIGHT OPERATIONS NOISE TESTS OF EIGHT HELICOPTERS**
S. A. YOSHIKAMI Aug. 1985 697 p
(AD-A159835; FAA/EE-85-7) Avail: NTIS HC A99/MF A02 CSCL 01C

This document presents acoustical data and flight path information acquired during the FAA/HAI Helicopter Flight

Operations Noise Test Program. As-measured noise levels of the Aerospatiale 365N, Agusta 109A, Bell 206L-1 and 222A, Hughes 500D, MBB BK117, Robinson R22, and Sikorsky S76 are presented for various enroute and heliport flight operations. These operations include level flyovers at two altitudes, normal takeoffs, normal and constant-glideslope approaches, various types of noise abatement approaches, level flight turns and hover (IGE and OGE). The acoustical data are accompanied by radar tracking data and cockpit instrument panel information which document the operational procedures flown, and meteorological measurements to permit data corrections for nonstandard atmospheric conditions. This helicopter operational noise data base can be used in enroute and heliport land use planning, heliport environmental studies and planning guidelines, pilot familiarization and training, verification of noise prediction and estimating methods, and lateral attenuation studies. GRA

**N86-19136#** Massachusetts Inst. of Tech., Lexington.
**DISTRIBUTED SENSOR NETWORKS Semiannual Technical Summary Report, 1 Oct. 1984 - 31 Mar. 1985**
R. T. LACOSS 26 Sep. 1985 32 p
(Contract F19628-85-C-0002; ARPA ORDER 3345; AF PROJ. 5D30; AF PROJ. 5T10)
(AD-A160596; ESD-TR-85237) Avail: NTIS HC A03/MF A01 CSCL 17B

The Distributed Sensor Networks (DSN) program is aimed at developing and extending target surveillance and tracking technology in systems that employ multiple spatially distributed sensors and processing resources. Such a system would be made up of sensors, data bases, and processors distributed throughout an area and interconnected by an appropriate digital data communication system. The detection, tracking, and classification of low flying aircraft has been selected to develop and evaluate DSN concepts in the light of a specific system problem. A DSN test bed has been developed and is being used to test and demonstrate DSN techniques and technology. The overall concept calls for a mix of sensor types. The initial test-bed sensors are small arrays of microphones at each node augmented by TV sensors at some nodes. This Semiannual Technical Summary (SATS) reports results for the period 1 October 1984 through 31 March 1985. Progress in the development of distributed tracking algorithms and their implementation in the DSN test-bed system is reviewed in Section II. Test-bed versions of distributed acoustic tracking algorithms now have been implemented and tested using simulated acoustic data. This required developing a solution to a basic distributed tracking problem: the information feedback problem. Target tracks received by one node from another node often implicitly include information that originally was obtained from the receiving node. GRA

**N86-19143#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**REPORT OF NOISE MEASUREMENTS WITH 2 DIFFERENT MICROPHONE DISPOSITIONS ON AIRPLANE TYPE CESSNA F 172L [VERSLAG VAN GELUIDSMETINGEN MET TWEE VERSCHILLENDE MICROFOONOPSTELLINGEN AAN HET VLIEGTUIGTYPE CESSNA F 172L]**
D. M. VANPAASSEN Apr. 1984 28 p refs In DUTCH
(VTH-M-510) Avail: NTIS HC A03/MF A01

The noise level of a Cessna F 172L in stationary symmetric horizontal engine flight at 1000 feet height was measured 14 times using 2 microphones placed above a white-sprayed aluminum plate and 1.2 m height above grassland, both horizontally directed to the arriving airplane. The measurements were carried out to determine the variation in noise certification measurements, and to verify a model for the determination of ground impact. The A-weighted noise spectra levels of the plane in overhead position are measured and averaged after flight height deviation corrections. Author (ESA)

**N86-20086*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**ACOUSTIC GUIDE FOR NOISE TRANSMISSION TESTING OF AIRCRAFT Patent Application**
R. VAICAITIS, inventor (to NASA) (Columbia Univ., N.Y., N.Y.) 3 Jul. 1985 13 p Sponsored by NASA
(NASA-CASE-LAR-13111-1-CU; NAS 1.71:LAR-13111-1-CU; US-PATENT-APPL-SN-751695) Avail: NTIS HC A02/MF A01 CSCL 20A

Selective testing of aircraft or other vehicular components without requiring disassembly of the vehicle or components was accomplished by using a portable guide apparatus. The device consists of a broadband noise source, a guide to direct the acoustic energy, soft sealing insulation to seal the guide to the noise source and to the vehicle component, and noise measurement microphones, both outside the vehicle at the acoustic guide output and inside the vehicle to receive attenuated sound. By directing acoustic energy only to selected components of a vehicle via the acoustic guide, it is possible to test a specific component, such as a door or window, without picking up extraneous noise which which may be transmitted to the vehicle interior through other components or structure. This effect is achieved because no acoustic energy strikes the vehicle exterior except at the selected component. Also, since the test component remains attached to the vehicle, component dynamics with vehicle frame are not altered. NASA

**N86-20088*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**STATUS AND CAPABILITIES OF SONIC BOOM SIMULATORS**
K. P. SHEPHERD and C. A. POWELL Jan. 1986 8 p refs
(NASA-TM-87664; NAS 1.15:87664) Avail: NTIS HC A02/MF A01 CSCL 20A

The current status and capabilities of sonic boom simulators which might be used in future studies of the effects of sonic boom on people, animals, or structures is summarized. The list of candidate simulators is based on a literature search which was confined to the United States and Canada. Some of the simulators are fully operational, others could be made operational with a modest investment, and still others would require a major investment. For the sake of the completeness, some simulators which were the subject of a previous review, but which no longer exist, are also included herein. Author

**N86-20089*#** Bolt, Beranek, and Newman, Inc., Canoga Park, Calif.
**IN-FLIGHT ACOUSTIC MEASUREMENTS ON A LIGHT TWIN-ENGINED TURBOPROP AIRPLANE Final Report**
J. F. WILBY, C. D. MCDANIEL, and E. G. WILBY Nov. 1985 233 p refs
(Contract NAS1-16521)
(NASA-CR-178004; NAS 1.26:178004) Avail: NTIS HC A11/MF A01 CSCL 20A

Four series of flight tests were conducted to measure sound pressure levels inside and outside the cabin of a twin-engined turboprop airplane. Particular emphasis was placed on harmonics of the propeller blade passage frequency. The cabin was unfurnished for the first three flights, when the main objective was to investigate the repeatability of the data. For the fourth flight, the cabin was treated with fiberglass batts. Typically, the exterior sound pressure levels were found to vary 3 to 5 dB for a given harmonic, but variations as high as 8 dB were observed. The variability of harmonic levels within the cabin was slightly higher but depended on control of the relative phase between the propellers; when phase was not controlled the average variability was about 10 dB. Noise reductions provided by the fuselage structure were in the range of 20 to 40 dB, when an exterior microphone in the plane of rotation of the propeller was used as reference. Author

**N86-20090#** Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.
**INTERNATIONAL CIVIL AVIATION ORGANIZATION HELICOPTER NOISE MEASUREMENT REPEATABILITY PROGRAM: US TEST REPORT, BELL 206L-1, NOISE MEASUREMENT FLIGHT TEST**
J. S. NEWMAN, E. J. RICKLEY, and M. LOCKE Sep. 1985 427 p
(AD-A159898; FAA/EE-85-6) Avail: NTIS HC A19/MF A01 CSCL 14B

This document reports the findings of the U.S test team's participation in the Helicopter Noise Measurement Repeatibility Program (HNMRP). The U.S./Canadian flight test was held in August of 1984 at Dulles International Airport near Washington, D.C. The principal objective of this international HNMRP is to refine noise certification testing requirements. Participating nations conducted the test programs on the same type helicopter, the Bell 206L-1 (or the acoustically equivalent 206L-3), using the same test procedures. Analyses in this document include the investigation of source noise adjustments based on increases in noise level with advancing blade tip Mach number, the examination of relative source contributions in the helicopter acoustical spectrum, and source directivity for both in-flight and static operations. This report contains helicopter noise definition information (useful in environmental impact analyses) for level flyovers at various airspeeds and altitudes, and ICAO takeoff and approach procedures. Data are also shown for a noise abatement operation involving dynamic changes in torque, rate of descent and airspeed. This report also provides information for the hover-in-ground effect, flight idle and ground idle static operations. GRA

**N86-20094#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
**B-52G CREW NOISE EXPOSURE STUDY**
W. H. DECKER and C. W. NIXON 30 Aug. 1985 49 p
(Contract AF PROJ. 7231)
(AD-A161112; AFAMRL-TR-85-056) Avail: NTIS HC A03/MF A01 CSCL 20A

The B-52G aircraft produces acoustic environments that are potentially hazardous, interfere with voice communications and may degrade task performance. Numerous reports from aircrew of high noise levels at crew location have been documented for those B-52G aircraft that have been modified with the Offensive Avionics System. To alleviate and minimize the excessive noise exposures of aircrews, a study of the noise problem in the b-52G was deemed necessary. First, in-flight noise measurements were obtained at key personnel locations on a B-52G during a typical training mission. Then, extensive laboratory analyses were conducted on these in-flight noise data. The resulting noise exposure data were evaluated in terms of the various segments of and the total flight profile relative to allowable noise exposures. Finally, recommendations were developed for short term and long term approaches toward potential improvement in the B-52G noise exposure problem. Author (GRA)

**N86-20095#** Institut Franco-Allemand de Recherches, St. Louis (France).
**EXPERIMENTAL STUDY OF THE ACOUSTIC FIELDS FAR AND NEAR A MICROTURBO TRS 18 TURBOREACTOR [ETUDE EXPERIMENTALE DES CHAMPS ACOUSTIQUES PROCHES ET LOINTAINS D'UN TURBOREACTEUR MICROTURBO TRS 18]**
C. JOHE and J. HAERTIG 26 Jun. 1984 42 p refs In FRENCH
(ISL-R-113/84) Avail: NTIS HC A03/MF A01

An experimental study was carried out to compare the acoustic field of a small turbojet with the field generated by a cold free jet excited or not. With subsonic jets the wide band noise shows a sinus variation associated to the turbine excitation. The azimuth field distribution is similar to that of the free jet. At maximum velocity the supercritical jet shows a far field similar to that of a nonexcited jet. The maximum emission is at a 30 deg angle, corresponding to the Oertel W Mach waves. Author (ESA)

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-25090**
**AIRCRAFT DESIGN AT KINGSTON POLYTECHNIC**
R. WHITFORD (Kingston Polytechnic, Kingston-upon-Thames, England) Aircraft Engineering (ISSN 0002-2667), vol. 57, Dec. 1985, p. 10-12.

The aeronautical engineering group design project at Kingston Polytechnic is described. The role of the project supervisor and the establishment of design teams are discussed. The utilization of computer packages which will provide specific aircraft information to the students in tabular or graphical form is examined. The interaction between the team members and related industries is analyzed. The organization of the data by the project coordinator in order to produce the final design report is discussed. I.F.

**N86-20165#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**RESEARCH AND DEVELOPMENT PROJECT SELECTION METHODS AT THE AIR FORCE WRIGHT AERONAUTICAL LABORATORIES M.S. Thesis**
J. R. PRINCE Sep. 1985 77 p
(AD-A161153; AFIT/GSM/LSY/85S-29) Avail: NTIS HC A05/MF A01 CSCL 14B

This thesis sought to determine how in-house research projects are selected at the U.S. Air Force Wright Aeronautical Laboratories (AFWAL). The problem was explored by studying ten aspects of the research project selection process. This analysis was accomplished by using a combination of personal and telephone interviews. Ten individuals from each of the four AFWAL Laboratories were interviewed. The results illustrated that few of the respondents used a formal decision method model when selecting research projects. Most of the in-house projects selected at AFWAL are chosen via a consensus of agreement between the various levels of management in each laboratory. GRA

## 18

## SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

**A86-22863#**
**ANALYSIS OF GAMMA RAY FAMILIES AND JETS UP TO 10 TO THE 7TH GEV OBTAINED DURING 1000 HOURS EXPOSURE OF EMULSION CHAMBERS ON THE CONCORDE**
J.-N. CAPDEVIELLE (Bordeaux I, Universite, Gradignan, France) IN: High energy astrophysics; Proceedings of the Fourth Moriond Astrophysics Meeting, La Plagne, France, February 27-March 2, 1984 . Gif-sur-Yvette, France, Editions Frontieres, 1984, p. 129-138. refs

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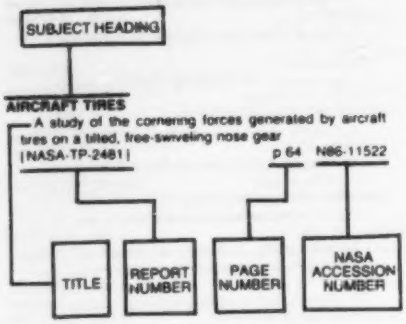
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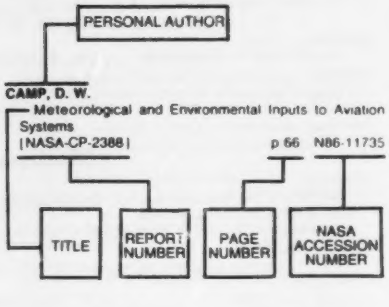

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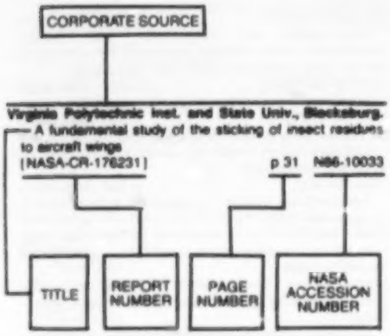
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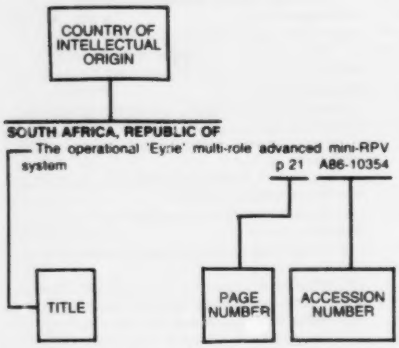
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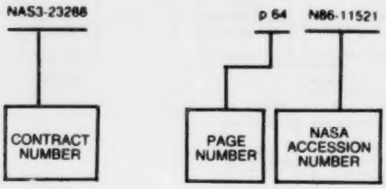

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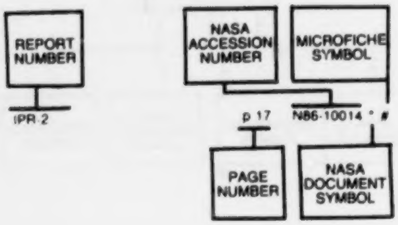

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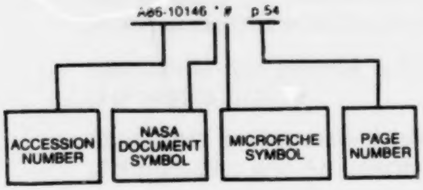

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A Continuing
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**Aeronautical Engineering**
A Continuing Bibliography with Indexes

Pages 335–403

July 1986

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## ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

| | |
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| STAR (N-10000 Series) | N86-20341 – N86-22536 |
| IAA (A-10000 Series) | A86-26300 – A86-29722 |

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NASA SP-7037(202)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY
## WITH INDEXES

## (Supplement 202)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in June 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Branch 1986
**National Aeronautics and Space Administration**
Washington, DC

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A06.

# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 447 reports, journal articles, and other documents originally announced in June 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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# TYPICAL CITATION AND ABSTRACT FROM *STAR*

NASA SPONSORED

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ACCESSION NUMBER → **N86-10033*#** Virginia Polytechnic Inst. and State Univ., ← CORPORATE SOURCE
Blacksburg. Dept. of Chemistry.
TITLE → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
AUTHORS → N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs ← PUBLICATION DATE
CONTRACT NUMBER → (Contract NAG1-300) ← AVAILABILITY SOURCE
REPORT NUMBERS → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF ← PRICE CODE
A01 CSCL 01C
COSATI CODE

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.
Author

# TYPICAL CITATION AND ABSTRACT FROM *IAA*

NASA SPONSORED

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ACCESSION NUMBER → **A86-11041*#** National Aeronautics and Space Administration.
Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS** ← TITLE
AUTHOR → D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) ← AUTHOR'S AFFILIATION
CONFERENCE TITLE → AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs ← CONFERENCE DATE
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.
Author

# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 202)*

JULY 1986

## 01

## AERONAUTICS (GENERAL)

**A86-27020**
**STRENGTH IN ADVERSITY**
H. HOPKINS Flight International (ISSN 0015-3710), vol. 129, Feb. 8, 1986, p. 24-26, 29.

Airworthiness aspects of the new alloys, composites, and hybrid materials appearing in increasing percentage in modern commercial aircraft are considered. Current metal alloys such as those of aluminum-lithium aim at strength, stiffness, and low weight, but their composition exposes them to stress concentration, fatigue, and corrosion. Aramid-reinforced aluminum laminate (Arall) with fracture toughness in addition to the qualities of composites has application for fatigue-critical parts, especially thin, stiffened wing structures. Airbus' experience with composite material (more expensive than metal, but with lower production and maintenance costs) suggests that metals alloys will offer much better weight reduction than any developments in composites until improvements in fibers are matched by advances in resin systems. For fail-safe and damage-tolerance certification, nondestructive testing is conducted using ultrasonic methods for composites, and mechanical impedance analysis for both metals and composites. According to the CAA the long-term European aim must be the acceptance of safe-life design only if damage tolerance is impracticable. R.R.

**A86-27145#**
**ELECTROMAGNETIC PULSE TEST AIRCRAFT (EMPTAC) PROGRAM**
D. I. LAWRY (USAF, Weapons Laboratory, Kirtland AFB, NM) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 373-375.

Electromagnetic pulses (EMP) which will only occur in the event of nuclear war represent a threat to modern weapon systems such as aircraft. The electromagnetic pulse test aircraft (EMPTAC) program is to provide a dedicated aircraft for conducting tests required in connection with EMP-related investigations. Attention is given to the EMP threat, past EMP efforts, details regarding the objectives of the EMPTAC program, the testbed aircraft, efforts in progress to support the development of subsystem and system level hardening specifications and associated verification testing, and aspects of hardness surveillance. Details of test technology are also considered along with a data analysis, questions of technology transition, and the challenge presented by the EMPTAC program. G.R.

**A86-27651**
**INTERNATIONAL CONFERENCE ON ROTORCRAFT BASIC RESEARCH, RESEARCH TRIANGLE PARK, NC, FEBRUARY 19-21, 1985, PROCEEDINGS**
Conference sponsored by AHS and U.S. Army. Alexandria, VA, American Helicopter Society, 1985, 352 p. For individual items see A86-27652 to A86-27669.

Various papers on rotorcraft basic research are presented. The subjects discussed include: analytical and experimental studies of textile structural composites, static postbuckling behavior of composite sandwich plates, optimal design of composite power transmission shafting, finite difference computations of rotor loads, semiempirical simulations of steady and unsteady rotor blade aerodynamic loading, wing/rotor and rotor/rotor interactions in tilt-rotor aircraft, helicopter model rotor-blade vortex interaction impulsive noise, and effects of side-stick controllers on rotorcraft handling qualities in terrain flight. Also addressed are: development of microcomputer codes for studying the flight dynamics and performance of helicopters, dynamic stability of hingeless and bearingless rotors in forward flight, structural dynamic aspects of rotor antiresonant isolation, kinematic observers for rotor control, aeroelastic stability analysis of a bearingless composite blade in hover, wake model for high resolution airloads, and prediction of flow around blade tips. C.D.

**A86-28306**
**ACCELERATED TESTING AS A MEANS OF ENSURING THE RELIABILITY OF AIRCRAFT EQUIPMENT [USKORENNYE ISPYTANIIA KAK SREDSTVO OBESPECHENIIA NADEZHNOSTI AVIATSIONNOI TEKHNIKI]**
A. V. MAIOROV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 17-24. In Russian.

The methodological principles of the design and execution of laboratory tests on aircraft equipment are examined. It is emphasized that by properly designing and conducting accelerated test programs, it is possible to obtain, within a short period of time, information on changes in the technical condition of aircraft systems that are equivalent to changes occurring under conditions of actual flight operations. A chart of the operating factors included in a basic test cycle is presented. V.L.

**A86-28521**
**AIRCRAFT OF SPECIAL CONFIGURATIONS [SAMOLETY OSOBYKH SKHEM]**
D. A. SOBOLEV Moscow, Izdatel'stvo Mashinostroenie, 1985, 136 p. In Russian. refs

Various nontraditional aircraft concepts are reviewed from a historical and a technical standpoint. Particular attention is given to the tailless and canard aircraft configurations and to the factors that have limited the widespread use of these configurations. Also presented is a brief history of some other nontraditional aircraft concepts, such as tandem configurations, circular-wing aircraft, and sweptforward wing aircraft, as well as some unrealized designs. V.L.

## 01 AERONAUTICS (GENERAL)

**N86-20342*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AEROELASTICITY AT THE NASA LANGLEY RESEARCH CENTER RECENT PROGRESS, NEW CHALLENGES**

P. W. HANSON Dec. 1985 76 p refs

(NASA-TM-87660; NAS 1.15:87660) Avail: NTIS HC A05/MF A01 CSCL 01B

Recent progress in aeroelasticity, particularly at the NASA Langley Research Center is reviewed to look at the questions answered and questions raised, and to attempt to define appropriate research emphasis needed in the near future and beyond. The paper is focused primarily on the NASA Langley Research Center (LaRC) Program because Langley is the lead NASA center for aerospace structures research, and essentially is the only one working in depth in the area of aeroelasticity. Historical trends in aeroelasticity are reviewed broadly in terms of technology and staffing particularly at the LaRC. Then, selected studies of the Loads and Aeroelasticity Division at LaRC and others over the past three years are presented with attention paid to unresolved questions. Finally, based on the results of these studies and on perceptions of design trends and aircraft operational requirements, future research needs in aeroelasticity are discussed. Author

**N86-21500#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

**DEVELOPMENT OF A COMPUTERISED METHOD OF DETERMINING AIRCRAFT MAINTENANCE INTERVALS M.S. Thesis**

D. B. OHEARN Sep. 1985 102 p

(AD-A16[illegible]339; AFIT/GLM/LSM/85S-59) Avail: NTIS HC A06/MF A01 CSCL 05A

Scheduled maintenance is considered one of the largest costs of aircraft ownership. For some components that exhibit an increasing failure rate, this cost can be minimized by changing the components at their optimal age replacement intervals which can be determined using the Total-Time-on-Test statistic. However, the age replacement model treats all components as separate entities and does not recognize economies that can be achieved by changing groups of components at the same time. This study develops a heuristic model for determination of near optimal groupings of components and the replacement intervals for these components. This heuristic model is illustrated using actual field data for a number of components fitted to the C130H aircraft engines operated by the Royal Australian Air Force. GRA

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-26409**

**AN ENGINEERING APPROACH TO THE INVERSE TRANSONIC WING DESIGN PROBLEM**

E. GREFF and J. MANTEL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) (International Conference on Inverse Design Concepts in Engineering Sciences, Austin, TX, Oct. 17-19, 1984) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 2, Jan.-Feb. 1986, p. 47-56. refs

The present state of the art in industrial wing design requires extensive configuration iterations through repeated wind tunnel test loops. The involved procedure is costly and time-consuming. It is, therefore, proposed to place greater emphasis on inverse design procedures in order to limit the number of wind tunnel models and reduce costly wind tunnel experiments. A new two-dimensional transonic direct inverse design method is presented, taking into account the use of a transonic direct code and a subsonic inverse code. The Direct Inverse Analogy Method (DIVA) considered takes advantage of the accuracy of subsonic airfoil design procedures and full potential transonic analysis methods. Attention is given to sample two-dimensional design cases, and aspects of transonic wing design. G.R.

**A86-26474**

**BASIC AERODYNAMICS**

C. B. STRIBLING London, Butterworths, 1984, 174 p. refs

It is the aim of this book to link computer programming with instruction in the fundamentals of aerodynamic theory. The book uses the BASIC language. An introduction to BASIC is provided, and the elements of fluid mechanics are examined, taking into account the properties of fluids, fluid statics, basic fluid dynamics, Reynolds number and Mach number, dimensional analysis, and similarity and wind tunnel testing. Other subjects investigated are related to stream function and velocity potential, the boundary layers, the airfoil section theory, finite wing theory, and supersonic flow. Attention is given to isentropic duct flow, a comparison of supersonic airfoil theories, pressures in a tip Mach triangle of a rectangular wing, the calibration of a Machmeter, shock waves, supersonic flow over curved surfaces and at corners, vortex theory, lifting line theory, lifting surface theory, properties of a specified wing, the lifting properties of a swept wing, the properties of a slender delta wing, thin airfoil theory, and boundary layer thicknesses. G.R.

**A86-27656#**

**SEMI-EMPIRICAL SIMULATION OF STEADY AND UNSTEADY ROTOR BLADE AERODYNAMIC LOADING**

U. LEISS (Muenchen, Hochschule der Bundeswehr, Munich, West Germany) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 15 p. refs

(Contract BMFT-LFF-83408)

A general formulation was developed to simulate the aerodynamic coefficients of a rotor blade at arbitrary angles of attack and Mach numbers by analytical expressions in steady and unsteady flow. The real aerodynamic behavior is simulated by the superposition of different flow types. Theory for a flat plate is the basis for the semi-empirical load simulation of arbitrary shapes. Only this physical superposition principle of steady flow enables a consistent formulation of unsteady effects. The difference between the method and measurement data is within the measurement accuracy. The comparison with other methods indicates a significant progress. The modular form of the model allows any refinement without any change of structure. In some cases analytical integration in radial direction is possible. Author

**A86-27666#**

**A WAKE MODEL FOR HIGH RESOLUTION AIRLOADS**

T. S. BEDDOES (Westland Helicopters, Ltd., Yeovil, England) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 12 p. refs

A rotor wake model has been constructed which identifies the important features of the wake and evaluates the local, dominant effects accurately. The greater part of the wake, which in this application is less important, is treated more approximately but still with small absolute error. Each turn of the spiral trailing vortex is considered, defining the geometry and determining the critical points relative to the portion of the blade under consideration. The induced velocity is then estimated by positioning large elements in critical locations and adding a remainder term for the rest of the spiral turn. A finite core model for the structure of the trailing vortices is included, and the influence of the relative local skew angle between the blade and vortex is considered. C.D.

**A86-27667#**
**FREE WAKE MODEL OF HOVERING ROTORS HAVING STRAIGHT OR CURVED BLADES**
A. ROSEN (Rensselaer Polytechnic Institute, Troy, NY) and A. GRABER (Technion Israel Institute of Technology, Haifa) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 16 p. refs

A free-wake model of hovering rotors or rotors in axial flight is derived. Straight or curved blades can be analyzed. The blades are modeled as lifting surfaces having one cell in the chordwise direction. The wake is divided into near and far regions. The near-wake is formed of straight vortex elements while semi-infinite helical vortex lines form the far wake. Results for two rotors having straight blades are presented. Convergence and stability of the numerical model are investigated. Comparison with experimental results shows good agreement in most of the cases. Author

**A86-27668#**
**THE PREDICTION OF FLOW AROUND BLADE TIPS**
B. E. WAKE, N. L. SANKAR, S. G. LEKOUDIS, and R. B. GRAY (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 10 p. Army-supported research. refs

The problem of predicting the aerodynamics of the flow around blade tips is reviewed, and the different methods for predicting that flowfield are discussed. A solution procedure, based on the Euler equations is developed, and it is coupled with Gray's wake model for hover, by splitting the flow variables into two components. One of the components is prescribed and the other is computed, while their sum satisfies the conservation laws. Calculations are presented for tip flows at transonic speeds and they are compared with measured data. Author

**A86-27669*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**RECONSTRUCTION OF A THREE-DIMENSIONAL, TRANSONIC ROTOR FLOW FIELD FROM HOLOGRAPHIC INTERFEROGRAM DATA**
Y. H. YU, J. K. KITTLESON (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), and F. BECKER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings (A86-27651 11-01). Alexandria, VA, American Helicopter Society, 1985, 26 p. Previously announced in STAR as N85-21112. refs
(AIAA PAPER 85-0370)

Holographic interferometry and computer-assisted tomography (CAT) are used to determine the transonic velocity field of a model rotor blade in hover. A pulsed ruby laser recorded 40 interferograms with a 2-ft-diam view field near the model rotor-blade tip operating at a tip Mach number of 0.90. After digitizing the interferograms and extracting fringe-order functions, the data are transferred to a CAT code. The CAT code then calculates the perturbation velocity in several planes above the blade surface. The value from the holography-CAT method compare favorably with previously obtained numerical computations in most locations near the blade tip. The results demonstrate the technique's potential for three-dimensional transonic rotor flow studies. Author

**A86-28525**
**AERODYNAMICS OF AIRCRAFT ELEMENTS [AERODINAMIKA ELEMENTOV LETATEL'NYKH APPARATOV]**
K. P. PETROV Moscow, Izdatel'stvo Mashinostroenie, 1985, 272 p. In Russian. refs

The aerodynamic characteristics of the principal aircraft components, such as airfoils, wings of finite length, lift-increasing devices, fuselage, and control elements, are examined in a systematic manner for various flight conditions. The discussion is based on the results of recent experimental studies and contains formulas for approximate aerodynamic calculations. Specific topics discussed include pressure distribution on an airfoil; aerodynamic characteristics of swept wings at low angles of attack in the subsonic and transonic ranges; characteristics of flow past bodies of high aspect ratios; and the effect of the cross-sectional shape of a body of high aspect ratio on its principal aerodynamic characteristics. Finally, some problems associated with the interference between individual aircraft components are examined. V.L.

**A86-28535#**
**A PERTURBATIVE LAMBDA FORMULATION**
A. DADONE and M. NAPOLITANO (Bari, Universita, Italy) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 411-417. Research supported by the Ministero della Pubblica Istruzione and CNR. refs

This paper provides a new perturbative lambda formulation for the numerical solution of compressible flows. The time-dependent Euler equations are recast into compatibility equations for perturbative bicharacteristic variables that are the differences between the standard Riemann variables and those corresponding to an appropriate steady incompressible flow. In this way, the geometry-induced gradients are accounted for by the incompressible flow solution and the smooth correction accounting for compressibility effects is solved accurately even on a coarse mesh. The new perturbative lambda equations for two-dimensinal homentropic flows are provided in a general orthogonal curvilinear coordinate system and solved numerically by means of an alternating direction implicit method. Results are presented for flow past a NACA 0012 airfoil that demonstrate the remarkable accuracy of the proposed methodology. Author

**A86-28558#**
**COMMENT ON 'CONICAL SIMILARITY OF SHOCK/BOUNDARY-LAYER INTERACTIONS GENERATED BY SWEPT AND UNSWEPT WINGS'**
S. M. BOGDONOFF (Princeton University, NJ) and S. WANG (Chinese Aerodynamics R&D Center, Sidhuan, People's Republic of China) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 540; Authors' Reply, p. 541, 542. refs

**A86-28565#**
**STEADY AND UNSTEADY TRANSONIC PRESSURE DISTRIBUTIONS ON NACA 0012**
H. TRIEBSTEIN (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 483-493) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 213-219. Previously cited in issue 22, p. 3172, Accession no. A84-44982. refs

**A86-28569*#** Vigyan Research Associates, Inc., Hampton, Va.
**AN ATTACHED FLOW DESIGN OF A NONINTERFERING LEADING-EDGE EXTENSION TO A THICK DELTA WING**
F. GHAFFARI (Vigyan Research Associates, Inc., Hampton, VA) and J. E. LAMAR (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 237-243. Previously cited in issue 07, p. 844, Accession no. A85-19689. refs

**A86-28637#**
**AN EXPERIMENTAL STUDY OF THE FLOW AND WALL PRESSURE FIELD AROUND A WING-BODY JUNCTION**
M. A. Z. HASAN, M. J. CASARELLA (Catholic University of America, Washington, DC), and E. P. ROOD (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Shear flow - Structure interaction phenomena; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 89-95. Navy-supported research. refs

The flow and the wall-pressure field around a wing-body junction has been investigated in a quiet, low-turbulence wind tunnel, measuring the point spectral densities along the centerline in front of the wing and along several spanwise locations. The strong adverse pressure gradient on the upstream centerline causes a three-dimensional flow separation at approximately one wing thickness upstream, inducing the formation of the horseshoe root vortex which wraps around the wing and becomes embedded within the boundary layer. Significant increases in the level of turbulence were observed both in the attached boundary layer and within the secondary flow. The data on the spectral content of the wall pressure fluctuations indicate that the increased levels of turbulence can be attributed to the low-frequency organized motion associated with the root vortex. I.S.

**A86-29415**

### THREE-DIMENSIONAL AND UNSTEADY BOUNDARY-LAYER COMPUTATIONS

J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Annual review of fluid mechanics. Volume 18 . Palo Alto, CA, Annual Reviews, Inc., 1986, p. 173-196. refs

Three-dimensional boundary layers which develop on a wing or fuselage of an aircraft, and unsteady boundary layers that are formed by imposed unsteadiness are studied. The coordinate system and equations for three-dimensional boundary layers are presented; the use of finite-difference methods to solve the equations is examined. The occurrence of singularities in two-dimensional and three-dimensional boundary layer computations is investigated. The development of turbulence models for two-dimensional and three-dimensional boundary layers is described; the effects of near-wall treatment on turbulence modeling is analyzed. I.F.

**A86-29417**

### VORTEX FLOWS IN AERODYNAMICS

J. H. B. SMITH (Royal Aircraft Establishment, Farnborough, England) IN: Annual review of fluid mechanics. Volume 18 . Palo Alto, CA, Annual Reviews, Inc., 1986, p. 221-242. refs

Planar vortex flows and three-dimensional flows from boundary-layer separation lines which arise in the external aerodynamics of aircraft, are studied. The difficulties encountered in modeling the Prandtl-Batchelor flows of an inviscid fluid past a two-dimensional body are examined. The characteristics of three-dimensional flows from swept separation lines, and the need to include secondary and turbulent separations in the modeling of the flows are described. The uses of the vortex-sheet model in the slender-body (SB) framework and the multiple line-vortex models in the SB and Prandtl-Glauert frameworks to represent and predict three-dimensional vortex flows are investigated. The inviscid modeling of vortex flow with the Euler equations, which take into account vorticity, is analyzed; examples revealing the applicability of Euler models are presented. I.F.

**A86-29474**

### TRANSONIC FLOW CALCULATIONS FOR AIRCRAFT

A. JAMESON (Princeton University, NJ) IN: Numerical methods in fluid dynamics . Berlin and New York, Springer-Verlag, 1985, p. 156-242. refs

The present evaluation of recent advancements in computational aerodynamics gives attention to the calculation of steady transonic flows over bodies of extreme geometric complexity, including those cases in which the domain is multiply connected, using either the potential flow equation or the Euler equations. The discussion encompasses the choice of a mathematical model, transonic potential flow equation upwind differencing, the treatment of complex geometric configurations, and convergence acceleration, as well as modification of the Euler equations for faster convergence to a steady state, the MacCormack and semidiscrete finite volume schemes, and viscous flow calculations. O.C.

**A86-29840**

### AERODYNAMICS. PART 1 - FUNDAMENTALS OF THEORY. AERODYNAMICS OF AN AIRFOIL AND A WING

N. F. KRASNOV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) Moscow, Mir Publishers, 1985, 512 p. Translation. refs

An introductory treatment of the aerodynamics of airfoils wings is presented. The fundamental theoretical problems of airfoil aerodynamics are considered, with emphasis given to: the equations of motion in viscous and inviscid flows; energy diffusion equations of gaseous media; and shock wave theory. Methods for calculating the stationary aerodynamic characteristics of airfoils and wings are discussed, including; the method of characteristics; Eulerian approaches; and Lagrangian methods. The application of flow calculations to specific aircraft designs is addressed in a companion volume. I.H.

**A86-29841**

### AERODYNAMICS. PART 2 - METHODS OF AERODYNAMIC CALCULATIONS

N. F. KRASNOV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) Moscow, Mir Publishers, 1985, 432 p. Translation. Previously cited in issue 15, p. 2351, Accession no. A82-33387. refs

**N86-20343#** Iowa State Univ. of Science and Technology, Ames. Coll. of Engineering.

### MODULAR APPLICATION OF A SHOCK/BOUNDARY LAYER INTERACTION SOLUTION TO SUPERCRITICAL VISCOUS-INVISCID FLOW FIELD ANALYSIS

G. R. INGER and W. G. HABASHI, ed. 1984 40 p refs
Reprinted from Computational Methods in Viscous Flows. Volume 3: Recent Advances in Numerical Methods in Fluids (Swansea, England), 1984 p 1-38
Avail: NTIS HC A03/MF A01

Shock boundary layer interaction influence extends significantly downstream within the boundary layer and thereby alters the global aerodynamic properties of lift, drag and pitching moment. Shock boundary layer interactions and their Reynolds and Mach number scaling must be fundamentally understood and appropriate theoretical tools be developed for their prediction in engineering applications. Features of an approximate nonasymptotic triple deck theory of shock turbulent boundary layer interaction and its application as an element in the overall viscous flow analysis of the body are described. Two main aspects of the problem are examined: local interactive thickening and skin friction drop in the shock foot region, including the effects of the incoming boundary layer shape factor, wall curvature, an improved viscous ramp model of the interaction and an approximate prediction of incipient separation behavior; and influence of such interaction on the subsequent downstream turbulent boundary layer thickening, profile shape and skin friction behavior. Comparisons with experimental data are given and applications presented for both supercritical airfoils and transonic bodies of revolution. Author

**N86-20344*#** George Washington Univ., Washington, D.C.

### EXPLORATORY LOW-SPEED WIND-TUNNEL STUDY OF CONCEPTS DESIGNED TO IMPROVE AIRCRAFT STABILITY AND CONTROL AT HIGH ANGLES OF ATTACK M.S. Thesis

D. E. HAHNE Dec. 1985 73 p refs Sponsored by NASA
(NASA-CR-176615; NAS 1.26:176615) Avail: NTIS HC A04/MF A01 CSCL 01A

A wind tunnel investigation of concepts to improve the high angle-of-attack stability and control characteristics of a high performance aircraft was conducted. The effect of vertical tail geometry on stability and the effectiveness of several conventional and unusual control concepts was determined. These results were obtained over a large angle-of-attack range. Vertical tail location, cant angle and leading edge sweep could influence both longitudinal and lateral-directional stability. The control concepts tested were found to be effective and to provide control into the post stall angle-of-attack region. Author

**N86-20345*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### EFFECT OF UNDERWING AFT-MOUNTED NACELLES ON THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A HIGH-WING TRANSPORT AIRPLANE

W. K. ABEYOUNIS and J. C. PATTERSON, JR. Dec. 1985 139 p refs
(NASA-TP-2447; L-15664; NAS 1.60:2447) Avail: NTIS HC A07/MF A01 CSCL 01A

As part of a propulsion/airframe integration program, tests were conducted in the Langley 16-Foot Transonic Tunnel to determine the longitudinal aerodynamic effects of installing flow through engine nacelles in the aft underwing position of a high wing transonic transfer airplane. Mixed flow nacelles with circular and D-shaped inlets were tested at free stream Mach numbers from 0.70 to 0.85 and angles of attack from -2.5 deg to 4.0 deg. The aerodynamic effects of installing antishock bodies on the wing and nacelle upper surfaces as a means of attaching and supporting nacelles in an extreme aft position were investigated. Author

**N86-20346*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### INSTALLATION EFFECTS OF LONG-DUCT PYLON-MOUNTED NACELLES ON A TWIN-JET TRANSPORT MODEL WITH SWEPT SUPERCRITICAL WING

E. E. LEE, JR. and O. C. PENDERGRAFT, JR. Dec. 1985 145 p refs
(NASA-TP-2457; L-15932; NAS 1.60:2457) Avail: NTIS HC A07/MF A01 CSCL 01A

The installation interference effects of an underwing-mounted, long duct, turbofan nacelle were evaluated in the Langley 16-Foot Transonic Tunnel with two different pylon shapes installed on a twin engine transport model having a supercritical wing swept 30 deg. Wing, pylon, and nacelle pressures and overall model force data were obtained at Mach numbers from 0.70 to 0.83 and nominal angles of attack from -2 deg to 4 deg at an average unit Reynolds number of 11.9 x 1,000,000 per meter. The results show that adding the long duct nacelles to the supercritical wing, in the near sonic flow field, changed the magnitude and direction of flow velocities over the entire span, significantly reduced cruise lift, and caused large interference drag on the nacelle afterbody. Author

**N86-20349*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AERODYNAMIC CHARACTERISTICS OF SEVERAL CURRENT HELICOPTER TAIL BOOM CROSS SECTIONS INCLUDING THE EFFECT OF SPOILERS

J. C. WILSON and H. L. KELLEY Jan. 1986 74 p refs
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TP-2506; L-15978; NAS 1.60:2506; AVSCOM-TR-85-B-3)
Avail: NTIS HC A04/MF A01 CSCL 01A

Aerodynamic characteristics were determined of three cylindrical shapes representative of tail boom cross sections of the U.S. Army AH-64, UH-60, and UH-1H helicopters. Forces and pressures were measured in a wind-tunnel investigation at the Langley Research Center. Data were obtained for a flow incidence range from -45 to 90 deg and a dynamic pressure range from 1.5 to 50 psf. These ranges provided data representative of full-scale Reynolds numbers and the full range of flow incidence to which these helicopter tail boom shapes would be subjected at low flight speeds. The effects of protuberances such as tail rotor drive-shaft covers and spoilers were evaluated. The data indicate that significant side loads on tail booms of helicopters can be generated and that the addition of spoilers can beneficially alter the side loads. Although an increase in vertical drag occurs, the net effect through reduction of tail rotor thrust required can be an improvement in helicopter performance. Author

**N86-20350*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### FLIGHT MEASUREMENTS OF SURFACE PRESSURES ON A FLEXIBLE SUPERCRITICAL RESEARCH WING

C. V. ECKSTROM Dec. 1985 120 p refs
(NASA-TP-2501; L-15877; NAS 1.60:2501) Avail: NTIS HC A06/MF A01 CSCL 01A

A flexible supercritical research wing, designated as ARW-1, was flight-tested as part of the NASA Drones for Aerodynamic and Structural Testing Program. Aerodynamic loads, in the form of wing surface pressure measurements, were obtained during flights at altitudes of 15,000, 20,000, and 25,000 feet at Mach numbers from 0.70 to 0.91. Surface pressure coefficients determined from pressure measurements at 80 orifice locations are presented individually as nearly continuous functions of angle of attack for constant values of Mach number. The surface pressure coefficients are also presented individually as a function of Mach number for an angle of attack of 2.0 deg. The nearly continuous values of the pressure coefficient clearly show details of the pressure gradient, which occurred in a rather narrow Mach number range. The effects of changes in angle of attack, Mach number, and dynamic pressure are also shown by chordwise pressure distributions for the range of test conditions experienced. Reynolds numbers for the tests ranged from 5.7 to 8.4 x 1,000,000. Author

**N86-20351*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### THE APPLICATION TO AIRFOILS OF A TECHNIQUE FOR REDUCING ORIFICE-INDUCED PRESSURE ERROR AT HIGH REYNOLDS NUMBERS

E. B. PLENTOVICH Jan. 1986 44 p refs
(NASA-TP-2537; L-16002; NAS 1.60:2537) Avail: NTIS HC A03/MF A01 CSCL 01A

A wind tunnel investigation was conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel to [illegible] the effects of porous (sintered metal) plug orifices [illegible] orifice-induced static-pressure measurement error at high Reynolds numbers. A NACA airfoil was tested at Mach numbers from 0.60 to 0.80 and at Reynolds numbers from 6 x 1,000,000 to 40 x 1,000,000. Data are included which compare pressure measurements obtained from porous plug orifices and from conventional orifices with diameters of 0.025 cm (0.010 in.) and 0.102 cm (0.040 in.). The two dimensional airfoil code GRUMFOIL was used to calculate boundary layer displacement thickness. The response time and the downstream effect of the porous plug orifice were considered in this investigation. The results showed that the porous plug orifice could be a viable method of reducing pressure error. The data also showed that the pressure measurements obtained with a 0.102-cm-diameter orifice were very close to the measurements obtained with 0.025-cm-diameter orifice over such of the airfoil and that downstream of a shock the orifice size was not critical. Author

**N86-20353#** National Aeronautical Lab., Tokyo (Japan).

### RESEARCH ON THE AERODYNAMIC CHARACTERISTICS OF VEHICLES BY FREE FLIGHT TESTING AT SUPERSONIC SPEEDS

I. KAWAMOTO Sep. 1985 74 p refs In JAPANESE; ENGLISH summary
(NAL-TR-876; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

A new free flight testing technique was developed in the 1mx1m blow-down supersonic wind tunnel. The following results were obtained: (1) a new launching method in which a model is installed inside the launcher was developed, and various models were successfully launched at various angles of attack; (2) a data processing program for moving models was developed by use of a parameter identification method under the assumption of three degrees of longitudinal freedom of motion; (3) cone models, Mercury capsule models, blunt cone capsule models, sounding rocket models and supersonic aircraft models were launched, results were obtained from the flight tests. There sometimes existed a short duration of the freedom motion, the data reduction to this partial duration of motion are in agreement with the conventional wind tunnel force test results in the aerodynamic coefficients, the divergence of the pitching motion of the Mercury Capsule model was shown in pictures; (4) the relations between the amount of data gathered during a run and the aerodynamic characteristics derived thererom are discussed; and (5) the excessive nonlinear terms of alpha for the aerodynamic expressions sometimes result in unacceptable aerodynamic characteristics. E.A.K.

**N86-20354#** National Aeronautical Lab., Bangalore (India). Fluid Mechanics Div.

**JET PLUME TEMPERATURE EFFECTS ON AFTERBODY PRESSURE DISTRIBUTION AND DRAG**

N. B. MATHUR and K. S. YAJNIK Mar. 1985 10 p refs
(NAL-TM-FM-8502) Avail: NTIS HC A02/MF A01

A typical axisymmetric configuration with a circular arc boattailed afterbody was investigated to study the jet plume temperature effects on afterbody pressure distribution and drag. The experiments which were carred out at a free stream Mach number of 0.62 and jet pressure ratio of about 3.0 show that as the jet temperature ratio is increased the afterbody pressures tend to increase and the afterbody pressure drag tends to decrease. It is a reduction in afterbody pressure drag by about 30 to 40% is shown when the jet plume temperature is increased from 307 deg K (cold jet) to 945 deg K. Both jet plume temperature and the afterbody surface temperature effects generally contribute to the observed changes in the pressure distribution and drag. E.A.K.

**N86-20356#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

**SIDE FORCE CHARACTERISTICS OF A 20 DEG CONE AT HIGH ANGLES OF ATTACK**

P. R. VISWANATH and K. Y. NARAYAN May 1985 24 p refs
(NAL-TM-AE-8503) Avail: NTIS HC A02/MF A01

Force measurements were made on a 20 deg. cone to study the features of side force generation at high angles of attack. The experiments covered a Mach number range of 0.17 to 0.25 and a Reynolds number range of 0.5 to 2.8x1,000,000. The model incidence was varied up to 47 deg. The magnitude of side forces and the onset angle of attack for side force generation are in fairly good agreement with other published data on cones. E.A.K.

**N86-20358*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF PLANFORM GEOMETRY ON HOVER PERFORMANCE OF A 2-METER-DIAMETER MODEL OF A FOUR-BLADED ROTOR**

A. E. PHELPS, III and S. L. ALTHOFF Mar. 1986 33 p refs
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-87607; L-16020; NAS 1.15:87607; AVSCOM-TR-85-B-6) Avail: NTIS HC A03/MF A01 CSCL 01A

Hover tests were conducted on three small scale rotors to evaluate the effects of blade planform taper on rotor hover performance. Tests were conducted on a rectangular swept-tip configuration, on a configuration with a 3 to 1 taper over the outboard 20 percent of the span, and on a configuration with a 5 to 1 taper over the outboard 20 percent of the blade span. The investigation covered a range of thrust coefficients from 0 to 0.0075 and a range of tip speeds from 300 to 600 ft/sec. The tests showed that both tapered configurations had better hover performance than the swept-tip rectangular configuration and that the 3 to 1 taper configuration was better than the 5 to 1 taper configuration. The test results were compared with predictions made with a prescribed wake analysis, a momentum analysis, and a simplified free wake analysis. Author

**N86-20360*#** Vigyan Research Associates, Inc., Hampton, Va.

**METHOD FOR THE PREDICTION OF THE INSTALLATION AERODYNAMICS OF A PROPFAN AT SUBSONIC SPEEDS: USER MANUAL**

B. CHANDRASEKARAN Jan. 1986 100 p refs
(Contract NAS1-17826)
(NASA-CR-178057; NAS 1.26:178057) Avail: NTIS HC A05/MF A01 CSCL 01A

This document is the user's guide for the method developed earlier for predicting the slipstream wing interaction at subsonic speeds. The analysis involves a subsonic panel code (HESS code) modified to handle the propeller onset flow. The propfan slipstream effects are superimposed on the normal flow boundary condition and are applied over the surface washed by the slipstream. The effects of the propeller slipstream are to increase the axial induced velocity, tangential velocity, and a total pressure rise in the wake of the propeller. Principles based on blade performance theory, momentum theory, and vortex theory were used to evaluate the slipstream effects. The code can be applied to any arbitrary three dimensional geometry, expressed in the form of HESS input format. The code can handle a propeller alone configuration or a propeller/nacelle/airframe configuration, operating up to high subcritical Mach numbers over a range of angles of attack. Inclusion of a viscous modelling is briefly outlined. Wind tunnel results/theory comparisons are included as examples for the application of the code to a generic supercritical wing/overwing Nacelle with a powered propfan. A sample input/output listing is provided. Author

**N86-20361*#** Vigyan Research Associates, Inc., Hampton, Va.

**SUBSONIC FLOW INVESTIGATIONS ON A CRANKED WING DESIGNED FOR HIGH MANEUVERABILITY Final Report**

D. M. RAO Feb. 1986 45 p refs
(Contract NAS1-17420)
(NASA-CR-178046; NAS 1.26:178046) Avail: NTIS HC A03/MF A01 CSCL 01A

The characteristic pitching moment nonlinearity of cranked wings limits their usable lift coefficient well below C sub L max. The potential of several aerodynamic devices, viz., fences, pylon vortex generators (PVG), mid-span strakes and cavity flaps, in delaying the pitch up onset on a 70/50 deg cranked wing was explored in low speed tunnel tests. Upper surface pressure measurements and low visualizations were conducted on a semi-span wing model to observe the vortex flow development with increasing angle of attack, and then to assess the effectiveness of the devices in controlling the collapse of vortex lift over the wing panel outboard of the crank. Force tests on a full span wing and body model were also conducted to assess the fence and PVG in improving the usable C sub L. Author

**N86-20362#** Aeronautical Research Labs., Melbourne (Australia).

**A VISUALISATION STUDY OF THE VORTEX FLOW AROUND DOUBLE-DELTA WINGS**

D. H. THOMPSON 1985 70 p refs
(ARL-AERO-R-165; AR-004-047) Avail: NTIS HC A04/MF A01

A family of double delta wings with leading edge sweep combinations of 80/80, 80/70, 80/60, 80/50, and 80/40 degrees was tested in a small towing tank. The hydrogen bubble technique was used to visualize the vortex patterns above the wings over a range of Reynolds numbers (based on centerline chord) from 7,000 to 100,000. The effects of variations in incidence and leading edge kink angle were examined. Reynolds number and leading edge cross section shape were found to have significant effects on the vortex structure. Attempts to visualize details of the upper surface secondary vortex flows met with only partial success. Author

**N86-20364#** National Aerospace Lab., Tokyo (Japan).
**NUMERICAL ANALYSIS OF INVISCID FLOWS ABOUT WING-FUSELAGE COMBINATIONS. 2: DEVELOPMENT OF FULL POTENTIAL FLOW CODE YOKUDO-P**
T. ISHIGURO 1985 87 p refs In JAPANESE; ENGLISH summary
(NAL-TR-881; ISSN-0389-4010) Avail: NTIS HC A05/MF A01

The main purpose of this paper is to numerically analyze inviscid flows about wing-fuselage combinations. In the second series a numerical procedure is developed for calculating full potential flows about wing-fuselage combinations by the successive-line-over-relaxation method of the rotated finite difference scheme, using the grids which have already been generated by the code YOKUDO-G in the first series. A user's manual for the FORTRAN code of the procedure is also described. Furthermore, many numerical examples are presented in order to show the utility of this code for flows about several wing-fuselage combinations under several free stream boundary conditions. The numerical results obtained by this code are compared with the experimental results and with numerical results of other methods.
Author

**N86-20368#** Naval Ship Research and Development Center, Bethesda, Md.
**LIFT DISTRIBUTION ON A HIGH ASPECT RATIO CIRCULATION CONTROL WING WITH ROOT LIFT CUTOUT Final Report, 1 Oct. 1982 - 1 Oct. 1983**
R. J. FUREY Jun. 1985 56 p refs
(AD-A157024; DTNSRDC-85/030; AR-1294) Avail: NTIS HC A04/MF A01 CSCL 20D

A computational procedure is developed, based on lifting line theory, which successfully predicts the spanwise lift distribution at moderate blowing momentum coefficient on a high aspect ratio (AR - 18) circulation control wing-body model with several variations in the spanwise extent of blowing. Experimental data are presented on the spanwise lift distribution which validates this procedure.
Author

**N86-20371#** Sandia National Labs., Albuquerque, N. Mex.
**DEVELOPMENT DROP TEST RESULTS OF THE 15-FT-DIA RIBBON PARACHUTE AND 73-FT-DIA CROSS PARACHUTE FOR THE US ARMY NATICK LABORATORY UHLCADS SYSTEM**
W. B. PEPPER Sep. 1985 27 p
(Contract DE-AC04-76DP-00789)
(DE85-017614; SAND-84-2183) Avail: NTIS HC A03/MF A01

During 1984 a series of 12 drop tests was conducted at the US Army Yuma Proving Ground near Yuma, Arizona to develop a new system to recover a 2200-lb resupply container from high altitude. The parachute system consists of a 15-ft-dia ribbon parachute reefed for 10 s and a 73-ft-dia cross parachute with no reefing. The system has been successfully demonstrated by flight tests. The impact velocity is 30 fps.
DOE

**N86-20374#** Technische Hogeschool, Eindhoven (Netherlands). Vakgroep Transportfysica.
**A REVISION OF THE ACTUATOR DISK CONCEPT AND MOMENTUM THEORY**
G. A. M. VANKUIK Aug. 1985 62 p refs
(REPT-R-732-D) Avail: NTIS HC A04/MF A01

The analytical solution of the singularity problem in the limit case of edge flow on a disk with constant surface load is analyzed, leading to an extension of the actuator disk concept with edge forces. If these forces are taken into account in the momentum theory, the results are more convincing, and nuclear experimental phenomena can be explained. The shift of the momentum theory results is only indicated qualitatively.
Author (ESA)

**N86-21504** Maryland Univ., College Park.
**COMPUTATION OF THREE DIMENSIONAL POTENTIAL FLOW AROUND A FINITE WING WITH A LEADING-EDGE DISCONTINUITY AT HIGH ANGLE OF ATTACK Ph.D. Thesis**
T. CHO 1985 219 p
Avail: Univ. Microfilms Order No. DA8523059

The aerodynamics of a finite wing above the stall angle of attack is investigated computationally. Vortex panel computer programs have been developed which can be used to calculate two dimensional separated flows over airfoils and three dimensional separated flow over a wing with leading edge droop modification. On each wind surface panel, a bound vortex is assumed to be distributed linearly in the spanwise direction and also in the chordwise direction. For the three dimensional flow around a finite thickness wing, the upper and lower surfaces are assumed to be independent infinitely thin wings located on top of each other. For three dimensional separated flow calculations, two different computational models are developed. One is a semi-empirical engineering model which is applied to an infinitely thin wing. The location of the separation and the pressure inside the separation region are provided from experiment. Inside the separation region, constant strength vortex panels are distributed corresponding to the constant pressure, Cp = -0.6, which is confirmed by various experiments.
Dissert. Abstr.

**N86-21508#** National Aerospace Lab., Tokyo (Japan).
**A VISCOUS-INVISCID INTERACTION METHOD TO PREDICT THE AERODYNAMIC PERFORMANCE OF AIRFOILS AT TRANSONIC SPEED**
K. MASUNO 1985 34 p refs In JAPANESE; ENGLISH summary
(NAL-TR-873) Avail: NTIS HC A03/MF A01

The present paper describes a calculation method for predicting the aerodynamic performance of single airfoils in the transonic flows of high Reynolds numbers. For the inviscid part of the method, a transonic full potential equation represented on an algebraically generated C-topology coordinate system is solved by a fully conservative AF2 iteration scheme. A finite difference method (PC-CN Scheme) is used for the boundary layer and wake solutions. In the viscous method, an algebraic turbulence model for the asymmetric near wake is also developed. The model used to achieve viscous-inviscid coupling is the equivalent source model. The wake thickness and curvature are taken into account. The calculations for turbulent wake flows indicated good agreement with the experimental data, and show that the velocity profiles across the wake and minimum velocities can be computed satisfactorily with the present method. Comparisons of the predictions with high Reynolds number wind tunnel experiments show good agreement for pressure distributions, lift and drag.
Author

**N86-21509*#** National Aeronautics and Space Administration, Washington, D.C.
**COMPARISON OF COMPUTATIONAL RESULTS OF A FEW REPRESENTATIVE THREE-DIMENSIONAL TRANSONIC POTENTIAL FLOW ANALYSIS PROGRAMS**
K. TANAKA and H. HIROSE Jan. 1986 19 p refs Transl. into ENGLISH of "Sanjigen Sen-Onsokunagare Kaisetsu Kakashu Puroguramu Niyoru Keisankekka no Hikaku" presented at the NAL Symposium on Aircraft Computational Aerodynamics, 1983 p 157-167 Symposium held in Tokyo, Japan, 30 Jun. - 1 Jul. 1983 Original language document was announced as N85-26628 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-3542)
(NASA-TM-77963; NAS 1.15:77963) Avail: NTIS HC A02/MF A01 CSCL 01A

The development of transonic aerodynamic computation methods and specific examples, as well as examples of three-dimensional transonic computation in design, are discussed. The case of the transonic transport and the case of the small transport are analyzed. Requirements for programs of the future are itemized.
Author

**N86-21510*#** National Aeronautics and Space Administration, Washington, D.C.
**VORTEX CONCEPTION OF ROTOR AND MUTUAL EFFECT OF SCREW/PROPELLERS**
A. M. LEPILKIN Jan. 1986 48 p refs Transl. into ENGLISH from Bulletin of the Academy of Sciences USSR, Mechanics and Machine Building (USSR), no. 5, 1963 p 77-107 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-77979; NAS 1.15:77979) Avail: NTIS HC A03/MF A01 CSCL 01A

A vortex theory of screw/propellers with variable circulation according to the blade and its azimuth is proposed, the problem is formulated and circulation is expanded in a Fourier series. Equations are given for inductive velocities in space for crews, including those with an infinitely large number of blades and expansion of the inductive velocity by blade azimuth of a second screw. Multiparameter improper integrals are given as a combination of elliptical integrals and elementary functions, and it is shown how to reduce elliptical integrals of the third kind with a complex parameter to integrals with a real parameter. Author

**N86-21511*#** National Aeronautics and Space Administration, Washington, D.C.
**PROPULSION AND CONTROL PROPELLERS WITH THRUSTER NOZZLES PRIMARILY FOR AIRCRAFT APPLICATIONS**
W. PABST Mar. 1986 8 p Transl. into ENGLISH of West German Patent no. P3440369.8 (5 Nov. 1984) p 1-6 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77715; NAS 1.15:77715) Avail: NTIS HC A02/MF A01 CSCL 01A

A propulsion and control propeller with thruster nozzles, primarily for aircraft application is described. Adjustability of rotor blades at the hub and pressurized gas expulsion combined with an air propeller increase power. Both characteristics are combined in one simple device, and, furthermore, incorporate overall aircraft control so that mechanisms which govern lateral and horizontal movement become superfluous. Author

**N86-21514*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**INTEGRATION EFFECTS OF UNDERWING FORWARD- AND REARWARD-MOUNTED SEPARATE-FLOW, FLOW-THROUGH NACELLES ON A HIGH-WING TRANSPORT**
M. LAMB and W. K. ABEYOUNIS Apr. 1986 31 p refs
(NASA-TM-87627; L-16026; NAS 1.15:87627) Avail: NTIS HC A03/MF A01 CSCL 01A

An experimental investigation was conducted in the Langley 16-Foot Transonic Tunnel at free-stream Mach numbers from 0.70 to 0.82 and angles of attack from -2.5 to 4.0 degrees to determine the integration effects of pylon-mounted underwing forward and rearward separate-flow, flow-through nacelles on a high-wing transonic transport configuration. The results showed that the installed drag of the nacelle/pylon in the rearward location was slightly less than that of the nacelle/pylon in the forward location. This reduction was due to the reduction in calculated skin friction of the nacelle/pylon configuration. In all cases the combined value of form, wave, and interference drag was excessively high. However, the configuration with the nacelle/pylon in a rearward location produced an increase in lift over that of the basic wing-body configuration. Author

**N86-21516*#** National Aeronautics and Space Administration, Washington, D.C.
**THREE-DIMENSIONAL BOUNDARY LAYER ANALYSIS PROGRAM BLAY AND ITS APPLICATION**
K. I. MATSUNO and T. ISHIGURO Jan. 1986 24 p refs Transl. into ENGLISH from proceedings of the NAL Symposium on Aircraft Computational Aerodynamics, 1983 p 207-218 Symposium held in Tokyo, Japan, 30 Jun. - 1 Jul. 1983 Original language document was announced as N85-26632 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77962; NAS 1.15:77962) Avail: NTIS HC A02/MF A01 CSCL 01A

The boundary layer calculation program (BLAY) is a program code which accurately analyzes the three-dimensional boundary layer of a wing with an undefined plane. In comparison with other preexisting programs, the BLAY is characterized by the following: (1) the time required for computation is shorter than any other; (2) the program is adaptable to a parallel processing computer; and (3) the program is associated with a secondary accuracy in the z-direction. As a boundary layer modification to transonic nonviscous flow analysis programs, it is used to adjust viscous and nonviscous interference problems repeatedly. Its efficiency is an important factor in cost reduction in aircraft designing. Transl. by B.G.

**N86-21518*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A NEW METHOD FOR LAMINAR BOUNDARY LAYER TRANSITION VISUALIZATION IN FLIGHT: COLOR CHANGES IN LIQUID CRYSTAL COATINGS**
B. J. HOLMES, P. D. GALL, C. C. CROOM, G. S. MANUEL, and W. C. KELLIHER Jan. 1986 9 p refs Original contains color illustrations
(NASA-TM-87666; NAS 1.15:87666) Avail: NTIS HC A02/MF A01 CSCL 01A

The visualization of laminar to turbulent boundary layer transition plays an important role in flight and wind-tunnel aerodynamic testing of aircraft wing and body surfaces. Visualization can help provide a more complete understanding of both transition location as well as transition modes; without visualization, the transition process can be very difficult to understand. In the past, the most valuable transition visualization methods for flight applications included sublimating chemicals and oil flows. Each method has advantages and limitations. In particular, sublimating chemicals are impractical to use in subsonic applications much above 20,000 feet because of the greatly reduced rates of sublimation at lower temperatures (less than -4 degrees Farenheit). Both oil flow and sublimating chemicals have the disadvantage of providing only one good data point per flight. Thus, for many important flight conditions, transition visualization has not been readily available. This paper discusses a new method for visualizing transition in flight by the use of liquid crystals. The new method overcomes the limitations of past techniques, and provides transition visualization capability throughout almost the entire altitude and speed ranges of virtually all subsonic aircraft flight envelopes. The method also has wide applicability for supersonic transition visualization in flight and for general use in wind tunnel research over wide subsonic and supersonic speed ranges. Author

**N86-21521#** Boston Univ., Mass. Center for Computational and Applied Dynamics.
**TWO METHODS FOR VISCOUS AND INVISCID FREE-WAKE ANALYSIS OF HELICOPTER ROTORS Final Report, 15 Feb. 1983 - 14 Apr. 1985**
L. MORINO and B. BHARADVAJ Aug. 1985 147 p
(Contract DAAG29-83-K-0050)
(AD-A161513; CCAD-TR-85-2; ARO-19797.3-EG) Avail: NTIS HC A07/MF A01 CSCL 20D

Two integral equation methods for the free wake analysis of helicopter rotors (for potential and rotational flows, respectively) have been presented. The rotational flow formulation is based upon Helmholtz scalar/vector-potential decomposition. The advantages of the rotational flow formulation over the potential flow formulation have been discussed. The numerical equivalence of the two methods have been demonstrated. It should be noted that (whereas in the potential flow problem viscosity may be introduced only as artificial viscosity) in the rotational-flow formulation the presence of viscosity is consistent with the formulation. Therefore, this formulation is applicable to the solution of time-averaged Navier-Stokes equations: in particular, a simplified thin-wake analysis with an elementary eddy-viscosity model for turbulence is used in the numerical applications. Analysis of the computer times indicates that the new formulation presented here (for rotational flows) has much broader applicability than the formulation for potential flows, while requiring approximately the same amount of computer time. GRA

**N86-22258#** Joint Publications Research Service, Arlington, Va.
**NUMERICAL ANALYSIS OF NONEQUILIBRIUM FLOW ABOUT AIRFOIL IN THIN SHOCK LAYER APPROXIMATION Abstract Only**
V. N. GOLUBKIN and V. V. NEGODA *In its* USSR Report: Physics and Mathematics (JPRS-UPM-86-003) p 5 5 Feb. 1986 Transl. into ENGLISH from Zhurnal Vychislitelnoy Matematiki i Matematicheskoy Fiziki (Moscow, USSR), v. 25, no. 4, Apr. 1985 p 599-608 Original language document was announced in IAA as A85-33593
Avail: NTIS HC A04

An efficient method is presented for solving nonlinear equations for a thin nonequilibrium shock layer on a low-aspect-ratio wing in hypersonic gas flow. The effect of the nonequilibrium of three-dimensional flow on the shape of the shock wave attached to the leading edge, pressure distribution, and the force and moment characteristics of the wing is discussed. Results of numerical calculations are presented. V.L

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-26640#**
**VERIFICATION AND APPLICATION OF THE ICING SCALING EQUATIONS**
G. A. RUFF (Sverdrup Technology, Inc., Middleburg Heights, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 25 p. refs
(AIAA PAPER 86-0481)

An experimental icing scaling research program was conducted at the Arnold Enginering Development Center which has verified a set of icing scaling equations for a limited range of icing conditions. By applying these equations, test conditions can be calculated so that ice accretion profiles are scaled to within the repeatability of the ice accretion measurement technique. The application of these scaling equations is discussed and a practical example of their solution is presented. Limitations of the method are also discussed. Author

**A86-28000**
**ULTRALIGHT AIRCRAFT - A NEED FOR BETTER REGULATION THAN 14 C.F.R. SECTION 103**
R. H. JACK (Jack and Jack, Athens, GA) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 51, Winter 1986, p. 415-460. refs

The need to eliminate the hazards to other aircraft from uncertified operators of ultralight vehicles is examined. The development of ultralight vehicles and civil aviation safety regulations is reviewed. The use of congressional legislation and executive agencies' regulations to control the hazards of ultralights is described. Judicial remedies which include the use of mandamus or tort action to solve the inadequacies of ultralight vehicle regulations are studied. The implementation of a licensing system for ultralight vehicle operators similar to the ones of Canada and Great Britain is proposed. I.F.

**A86-28564*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MEASUREMENTS OF THE RESPONSE OF TRANSPORT AIRCRAFT CEILING PANELS TO FUEL FIRES**
C. P. BANKSTON and L. H. BACK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 207-212. NASA-supported research. Previously cited in issue 07, p. 851, Accession no. A85-19720. refs

**A86-28571#**
**THRUST-VECTORED TAKEOFF, LANDING, AND GROUND HANDLING OF AN AIRSHIP**
B. L. NAGABHUSHAN and N. P. TOMLINSON (Goodyear Aerospace Corp., Akron, OH) (Lighter-Than-Air Systems Conference, 6th, Norfolk, VA, June 26-28, 1985, Technical Papers, p. 100-107) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 250-256. Research supported by the Goodyear Independent Research and Development Program. Previously cited in issue 18, p. 2613, Accession no. A85-38792. refs

**N86-20377#** National Transportation Safety Board, Washington, D. C.
**SAFETY STUDY: ULTRAVIOLET VEHICLE ACCIDENTS Safety Study Report, Mar. 1983 - Sep. 1984**
2 Jul. 1985 406 p refs
(PB85-917001; NTSB/SS-85/01) Avail: NTIS HC A18/MF A01

Since 1982, the Federal Aviation Administration (FAA) has regulated the operation of ultralight vehicles under 14 CFR Part 103. Increasing numbers of reports of ultralights being operated in regulated airspace and for nonrecreational purposes made it apparent to the Safety Board that an evaluation of the effectiveness of the FAA's regulatory approach to ultralights was needed. In the absence of a systematic accident data collection process on which to base the analysis, the Safety Board in March 1983 decided to investigate all fatal accidents involving a powered ultralight and other selected powered ultralight accidents involving obvious safety issues. Between March 1983 and September 1984, the Safety Board investigated 177 ultralight accidents, of which 88 involved a total of 93 fatalities. The Safety Board has prepared a report which describes the safety problems identified through analyses of these accidents, explores safety concerns raised by organizations and associations interested in ultralights, and recommends improvements in existing ultralight safety measures, where appropriate. Author

**N86-20378#** RMS Technologies, Inc., Trevose, Pa.
**GALLEY AND OVERHEAD COMPARTMENT EXPERIMENT RESULTS: FULL-SCALE TRANSPORT CONTROLLED IMPACT DEMONSTRATION Final Report, Jun. 1981 - Dec. 1985**
R. M. LLOYD and D. JOHNSON Dec. 1985 57 p refs
(Contract DTFA03-81-C-00040)
(DOT/FAA/CT-85/33) Avail: NTIS HC A04/MF A01

An air-to-ground impact test demonstration was conducted with a remotely piloted transport category airplane. The Full-Scale Transport Controlled Impact Demonstration Program (CID) is discussed. The program includes activities involved in the development and subsequent demonstration of an antimisting fuel experiment and experiments relating to improvements in cabin fire safety and structural impact protection. The results of structural experiments associated with two onboard galleys and overhead stowage compartments are reported. During the impact demonstration, both compartments remained in place without spillage of their internal contents, while the post crash fire resulted in minor galley damage and total destruction to the overhead compartments. E.A.K.

**N86-20379*#** Wichita State Univ., Kans.

**PARTICLE TRAJECTORY COMPUTATION ON A 3-DIMENSIONAL ENGINE INLET Final Report Ph.D. Thesis**

J. J. KIM Jan. 1986 115 p refs
(Contract NAG3-566)
(NASA-CR-175023; NAS 1.26:175023; DOT-FAA-CT-86-1) Avail: NTIS HC A06/MF A01 CSCL 01C

A 3-dimensional particle trajectory computer code was developed to compute the distribution of water droplet impingement efficiency on a 3-dimensional engine inlet. The computed results provide the essential droplet impingement data required for the engine inlet anti-icing system design and analysis. The droplet trajectories are obtained by solving the trajectory equation using the fourth order Runge-Kutta and Adams predictor-corrector schemes. A compressible 3-D full potential flow code is employed to obtain a cylindrical grid definition of the flowfield on and about the engine inlet. The inlet surface is defined mathematically through a system of bi-cubic parametric patches in order to compute the droplet impingement points accurately. Analysis results of the 3-D trajectory code obtained for an axisymmetric droplet impingement problem are in good agreement with NACA experimental data. Experimental data are not yet available for the engine inlet impingement problem analyzed. Applicability of the method to solid particle impingement problems, such as engine sand ingestion, is also demonstrated. Author

**N86-20380*#** Toledo Univ., Ohio. Coll. of Engineering.

**A NUMERICAL AND EXPERIMENTAL INVESTIGATION OF ELECTROCHEMICAL AIRCRAFT DEICING M.S. Thesis Final Report**

K. L. LEFFEL Jan. 1986 268 p refs
(Contract NAG3-72)
(NASA-CR-175024; NAS 1.26:175024) Avail: NTIS HC A12/MF A01 CSCL 01C

This study was composed of three parts. The first part involved the extension of an existing transient two dimensional numerical code for an electrothermal deicer so that it would simulate the situation where a variable thickness ice layer existed at the outer surface. The Enthalpy Method was used to simulate the phase change, and Gauss-Seidel iteration was used to solve the resulting system of finite difference equations. A set of criteria were developed for determining when a variable thickness ice layer had an effect on deicer performance. The second part was the acquisition and analysis of experimental data. The test model was a section of a Bell UH-1H helicopter blade equipped with an electrothermal deicer. A total of fifty-two thermocouples were utilized to document the thermal response of the blade and decier assembly. In the deicing runs, the experimental temperature response data clearly showed when melting, shedding or refreezing occurred. The tests illustrated that the criterion for shedding in the three cases where it did occur was that the abrasion shield interface temperature was 32 to 34 F. The third part concerned the validation of a one dimensional transient thermal model of an electrothermal deicer by comparison of the predictions with the experimental data. The Enthalpy Method was found to effectively model the phase change which occurred, and the ice shedding algorithm employed in the simulation was also evaluated. Author

**N86-21525#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.

**AIRCRAFT ACCIDENT REPORT: AIR CANADA FLIGHT 797, MCDONNELL DOUGLAS DC-9-32, C-FTLU GREATER CINCINNATI INTERNATIONAL AIRPORT, COVINGTON, KENTUCKY, JUNE 2, 1983 Accident Report, 2 Jun. 1983**

31 Jan. 1986 118 p refs
(PB86-910402; NTSB/AAR-86-02) Avail: NTIS HC A06/MF A01 CSCL 01C

A fire aboard a McDonnell Douglas DC-9-32, at the Greater Cincinnati International Airport, Covington, Kentucky, and the death of 23 passengers is reported. A fire in the aft lavatory was discovered while in flight and an emergency descent was made. Airport support, escape measures, and fire fighting are described. It was determined that the probable causes of the accident were: (1) a fire of undetermined origin; (2) an underestimate of fire severity; and (3) misleading fire progress information provided to the captain. It is concluded that the time taken to evaluate the nature of the fire and to decide to initiate an emergency descent contributed to the severity of the accident. E.A.K.

**N86-21526#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.

**AIRCRAFT ACCIDENT REPORT: GALAXY AIRLINES, INC., LOCKHEED ELECTRA-L-188C, N5532, RENO, NEVADA, JANUARY 21, 1985**

4 Feb. 1986 89 p
(PB86-910401; NTSB/AAR-86-01) Avail: NTIS HC A05/MF A01 CSCL 01C

About 0102:30 Pacific standard time on January 21, 1985, Galaxy Airlines Flight 203, a Lockheed Electra charter flight en route to Minneapolis, Minnesota, departed runway 16R of the Reno-Cannon International Airport. Approximately one minute later, the crew requested a turn to a left downwind to return to the airport because of a vibration in the airplane. In accordance with the request, the tower controller cleared the flight to make a left turn to a downwind traffic pattern. The airplane crashed at 0104 into an area 1 1/2 miles from the departure end of runway 16R, and 3/4 mile to the right of the extended runway centerline. The impact and subsequent fire killed the crew of six and 64 of the 65 passengers onboard. The airplane was destroyed. The sky was clear and the visibility was 12 miles at the time of the accident. The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to control and the copilot's failure to monitor the flight path and airspeed of the aircraft. This breakdown in crew coordination followed the onset of unexpected vibration shortly after takeoff. Contributing to the accident was the failure of ground handlers to properly close an air start access door, which led to the vibration. Author

**N86-21527#** Flight Safety Foundation, Inc., Arlington, Va.

**PROCEEDINGS OF CABIN SAFETY CONFERENCE AND WORKSHOP HELD ON 11-14 DECEMBER 1984 Final Report**

Aug. 1985 221 p Conference and Workshop held 11-14 Dec. 1984
(AD-A160950; DOT/FAA/ASF-100-85/01; DOT-TSC-FAA-85-6) Avail: NTIS HC A10/MF A01 CSCL 01B

These proceedings contain formal conference presentations as well as summaries of informal workshop discussions on how to further improve aircraft cabin occupant safety. The overall objective of the conference is increased communication between various segments of the aviation community in the area of aircraft safety. Also included are the FSF's analysis and future recommendations for occupant safety. Topics covered include: overview of aircraft occupant safety problems; cabin safety initiatives; inflight occupant protection; crash and fire protection; evacuation and survival; economics and regulatory considerations. GRA

**N86-21528#** Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

**AIRCRAFT MISHAP FIRE PATTERN INVESTIGATIONS Final Report, 1 Jun. 1984 - 31 Jul. 1985**

J. M. KUCHTA (Green International, Inc., Sewickley, Pa.) and R. G. CLODFELTER Aug. 1985 190 p
(Contract F33615-83-C-2359)
(AD-A161094; AFWAL-TR-85-2057) Avail: NTIS HC A09/MF A01 CSCL 01B

This manual was prepared to provide the aircraft mishap investigator with state-of-the-art data and guidelines for investigating aircraft fires and explosions. Sections are included on investigating procedures, properties of air atmospheres, properties of aircraft combustibles (liquids, gases, or solids), properties of ordnance explosives, and damage analyses relating to fires and explosions. Procedures for accumulating, developing, and analyzing the evidence are outlined, and various combustion data are summarized for use in determining the ignition source, combustible source, and mishap scenario. To help establish the mishap scenario, damage criteria are given in terms of material or biological response to fire temperatures, explosion pressures, toxic gases, and other potentially hazardous exposures. Methods for calculating combustion quantities and damage potentials, including material failures, are included in this manual. Author (GRA)

**N86-21529#** Federal Aviation Administration, Atlantic City, N.J.
**AIRCRAFT INTERIOR PANEL TEST CRITERIA DERIVED FROM FULL-SCALE FIRE TESTS Final Report**
R. G. HILL, T. I. EKLUND, and C. P. SARKOS Sep. 1985 65 p
Original contains color illustrations
(AD-A161637; FAA/CT-85/23) Avail: NTIS HC A04/MF A01
CSCL 01B

Full-scale cabin fire tests were conducted to determine potential increases in passenger survivability associated with different interior honeycomb panel constructions. The test fuselage was a C-133 with a simulated wide-body door opening exposed to an 8-foot by 10-foot fuel fire. In the first series, the interior near the door was lined with the honeycomb panels to determine whether earlier studies performed with small-scale enclosures were consistent with the full-scale counterpart. These earlier studies resulted in the selection of the Ohio State University (OSU) Rate of Heat Release Apparatus as the most appropriate type test to evaluate aircraft panels. The first series was followed by tests that included fire-blocked seats and carpeting as well as the panels to determine the type survivability increases that could be attained from low heat release materials. The scenario employed generally resulted with flashover within 2 minutes for panels considered typical in performance. A low heat release phenolic/fiberglass panel demonstrated a flashover delay until about 4 minutes into the test. An incombustible panel prevented flashover altogether. The performance of the various panels was evaluated to develop recommended flammability criteria for a modified OSU Rate of Heat Release Apparatus. GRA

**N86-21530#** Transportation Systems Center, Cambridge, Mass.
**GENERAL AVIATION PILOT AND AIRCRAFT ACTIVITY SURVEY Final Report, 1984**
C. FRANK and J. OHMAN Sep. 1985 83 p Prepared in cooperation with Automated Sciences Group, Inc., Silver Spring, Md.
(Contract DTRS-57-84-C-00100)
(AD-A161665; TSC-FAA-85-7; FAA-MS-85-1) Avail: NTIS HC A05/MF A01 CSCL 14B

A summary and analysis of the data collected in the 1984 General Aviation Pilot and Aircraft Activity Survey is provided. The survey was conducted at a random sample of general aviation airports across the nation throughout the months of July, August, September, and October, 1984 by the Federal Aviation Administration with the assistance of the Civil Air Patrol. The survey data provide information regarding the magnitude and characteristics of general aviation including: type and source of weather information services, trip length in time and distance, and pilot age and certification. Estimates are made of total 1984 general aviation operations, fuel consumption and aircraft miles flown. GRA

# 04

# AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-26438*#**
**HELICOPTER FLIGHT TEST DEMONSTRATION OF DIFFERENTIAL GPS**
R. P. DENARO and J. BESER (TAU Corp., Los Gatos, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 116-121. NASA-sponsored research. refs

An off-line post-mission processing facility is being established by NASA Ames Research Center to analyze differential GPS flight tests. The current and future differential systems are described, comprising an airborne segment in an SH-3 helicopter, a GPS ground reference station, and a tracking system. The post-mission processing system provides for extensive measurement analysis and differential computation. Both differential range residual corrections and navigation corrections are possible. Some preliminary flight tests were conducted in a landing approach scenario and statically. Initial findings indicate the possible need for filter matching between airborne and ground systems (if used in a navigation correction technique), the advisability of correction smoothing before airborne incorporation, and the insensitivity of accuracy to either of the differential techniques or to update rates. Author

**A86-26440#**
**A SURVEY OF COMMERCIALLY AVAILABLE POSITIONING SYSTEMS**
S. R. SAMPSON (Cubic Corp., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 162-166.

The requirement to accurately position and track a moving aircraft, vehicle or vessel requires the user to select from an often bewildering array of commercial positioning systems. Each offers a different combination of range, accuracy, dynamics, operational modes and inherent limitations. This paper presents a tabular summary of the available commercial systems and their key specifications. Supporting text uses the transmitted frequency band to divide the systems into generic categories with generally common performance. Within each group, the characteristic capabilities and limitations are discussed. Topics include GDOP, calibration, multipath, skywave, propagation velocities, frequency allocation and measurement ambiguities. The reader will find the paper provides the basic navigation aids required to chart a safe course through the maze of systems available. Author

**A86-26442#**
**OMEGA - COMMERCIAL EXPERIENCES WITH A MATURE SYSTEM**
G. GIBBS (Canadian Marconi Co., Montreal, Canada) and H. BANSBACH (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 183-190. refs

The operation of Omega equipment within the commercial airborne community is reviewed. The development of the automated, economical navigation system which employs hyperbolic or rho-rho-rho principles is examined. The applications of Omega systems to land, sea, and air navigation by military and commercial operators are described and a list of commercial users of the system is provided. The problems encountered with the installation of the Omega receiver antenna on the aircraft, distinguishing short and long path signals, and the Omega coverage and signal geometry, and the facilities used to maintain the equipment are analyzed. I.F.

**A86-26443#**
**DECENTRALIZATION FILTERING AND REDUNDANCY MANAGEMENT/FAILURE DETECTION FOR MULTISENSOR INTEGRATED NAVIGATION SYSTEMS**
T. KERR (Intermetrics, Inc., Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 191-208. refs

Current failure detection isolation and reconfiguration procedures applicable to navigation systems are reviewed. The design of a failure detection/redundancy management technique which incorporates voter monitoring methodology, decentralized Kalman filter mechanization, and a semiautonomous multisensor navigation system is described. The technique involves the use of Gaussian confidence regions to account for the inherent difference in accuracy between the various sensor subsystems and on-line estimates of covariances from the Kalman filter are utilized for this assessment. The technique evaluates the probability of detecting failed component subsystems and the probability of false alarms to be incurred. The development of a Kalman filter on a chip is analyzed. I.F.

**A86-26444#**
**MICROWAVE LANDING SYSTEM (MLS)**
J. J. STRONG (Hazeltine Corp., Commack, NY) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 209-218.

The Microwave Landing System (MLS) which uses microwave frequencies in the 5000 MHz range and 200 operating channels to provide azimuth and elevation guidance, and continuous range information to aircraft is examined. A scanning beam concept in which the time differences between two scans of the azimuth and elevation antennas are measured to obtain angular guidance data is employed in the MLS. The azimuth, elevation and back azimuth stations, and data links of the MLS are described. The precision distance measuring equipment transponder produces range data and operates in initial and final approach modes. The implementation of the MLS worldwide for military and civilian applications, and the FAA's national implementation program for the MLS are discussed. I.F.

**A86-26501**
**INSTITUTE OF NAVIGATION, ANNUAL MEETING, 41ST, U.S. NAVAL ACADEMY, ANNAPOLIS, MD, JUNE 25-27, 1985, PROCEEDINGS**
Meeting supported by the Bell Aerospace Textron, Charles Stark Draper Laboratory, Inc., Dynamics Research Corp., et al. Washington, DC, Institute of Navigation, 1985, 124 p. For individual items see A86-26502 to A86-26512.

Among the topics discussed are: tensor products in signal processing for satellite navigation applications; satellite selection criteria for altimeter aiding of GPS; and application of GPS to weapons systems. Consideration is also given to commercial aviation GPS navigation set test flight data; civil helicopter flight; operations using differential GPS; onboard rendezvous navigation for the Space Shuttle; and Chinese commercial navigation systems. Additional topics include: Space Station navigation design issues; the contribution of handheld computers to space navigation in the future; and automatic sextant development for space applications. I.H.

**A86-26507#**
**COMMERCIAL AVIATION GPS NAVIGATION SET FLIGHT TEST RESULTS**
A. K. BROWN and M. A. STURZA (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 41-48.

This paper presents lab test and flight test results obtained with the LTN-700 GPS Navigation Set. The LTN-700 is the first GPS Navigation Set specifically designed for commercial aviation applications. Its architecture was previously described at the ION National Technical Meeting, January, 1984. The difficulties encountered in instrumenting the flight tests of a system as precise as GPS are discussed. Static lab test results are shown to demonstrate absolute navigation accuracy. Flight testing of the LTN-700 has been conducted on Litton Systems' Merlin IV aircraft. Data is presented showing the receiver tracking performance in a commercial aviation environment. Comparative data showing the performance of the LTN-700 and a high quality Inertial Navigation System (INS) is provided. Other LTN-700 tests are also briefly described. Author

**A86-26509*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**CIVIL HELICOPTER FLIGHT OPERATIONS USING DIFFERENTIAL GPS**
F. G. EDWARDS (NASA, Ames Research Center, Moffett Field, CA) and P. V. W. LOOMIS (TAU Corp., Los Gatos, CA) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 54-63. refs

The results of NASA flight trials of a dual-receiver differential global positioning system (DGPS) for civilian helicopter navigation applications, are presented. The three principal components of the DGPS system are described, including the GPS ground-reference system, a range tracking system, and an on-board sequential GPS receiver. The ground-based receiver in the DGPS operates at a known fixed location and receives C/A code signals from NAVSTAR satellites. System bias errors in the ground receiver are subtracted from the airborne solution for the navigational fix. Calculations of the differential bias error are carried out using an on-board PDP-11/34 M research computer. The ground-reference differential corrections for satellites are given in a table. It is shown that the differential correction signal of the DGPS contains only a small (0.1 rad/sec) high-frequency component which can be attributed to system error. A schematic diagram of the DGPS postflight data processing routine is provided. I.H.

**A86-27128#**
**AIRCRAFT COUPLING MODEL EVALUATIONS AT SHF/EHF**
G. GENELLO and A. PESTA (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 72-74. refs

Severe overcrowding of the RF spectrum, especially at UHF, has been one primary motivator to extend military communications into the SHF and finally the EHF band. The potential interference of placing new SHF/EHF terminals on-board existing and new aircraft platforms is unknown and must be assessed. Several EMC-related computer analysis programs are available to predict the coupling between aircraft antennas. However, the models contained in these codes may not be adequate for prediction analysis at these higher frequencies. Coupling measurements have been performed on a KC-135 style aircraft and a F-16 tactical fighter to evaluate the validity of the computer models. A comparison analysis of predicted and actual coupling data is presented. Author

**A86-27784**
**THE MCDONNELL AIRCRAFT TELEMETRY TRACKING SYSTEM AT EDWARDS AIR FORCE BASE, CA**
J. L. HANEY and C. O. HILGARTH (McDonnell Aircraft Co., St. Louis, MO) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 101-106.

McDonnell Aircraft Company recently completed installation of a telemetry tracking system at their Edwards Air Force Base, CA flight test facility. A discussion of the planning, specifications, acquisition, installation, operation, as well as observations and comments about the system is presented from a user's perspective. Author

**A86-27789**

**REAL-TIME TELEMETRY OF COMPLETE 1553 DATA BUSES**

P. M. BREEDLOVE and C. R. STEPHENS (Loral Corp., Loral Instrumentation, San Diego, CA) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 167-174.

As MIL-STD-1553 Multiplex Data Bus usage proliferates, the ability to remotely monitor bus traffic has become important. Common applications include flight testing of missiles and aircraft, and the field maintenance of vehicles. Due to the high data rate and asynchronous characteristics of the 1553 Data Bus special problems exist in the acquisition and analysis of 1553 bus traffic. The acquisition of the complete bus traffic is especially important during system testing and diagnostic operations. Several approaches are being utilized today to transmit 1553 bus traffic. The first approach is an extension of the PCM technique in which all of the bus traffic, during a specific time window, is buffered and then output in a PCM style format. This has the advantage of being synchronous, but a significant amount of bus information is lost, primarily the protocol and bus timing. An alternative approach is to transmit raw unbuffered bus traffic. Bus timing and protocol are retained, but the telemetry signal is asynchronous. A third approach, developed by Loral Data Systems in conjunction with Loral Instrumentation, is a 1553 Data Acquisition System that retains bus timing and protocol and synchronizes the signal to a common clock. Author

**A86-27804**

**TSPI DATA PROCESSING IN THE TELEMETRY ENVIRONMENT**

G. REED (Computer Sciences Corp., Lompoc, CA) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 333-343.

Most test ranges are required to process both telemetry and Time Space Position Information (TSPI) data in real time. Using the Integrated Flight Data Processing System (IFDAPS) at Edwards AFB as an example, some of the basic differences between telemetry and TSPI data processing are identified and methods of integrating the two types of processing are discussed. Included for consideration in the integrated processing are data acquisition, measurement displays, recording, derived measurement computations using both types of data, and post flight merging of telemetry and TSPI data. Data processing is discussed in a concurrent, multiple operation environment using separate, integrated processors. Author

**A86-27813**

**REMOTE AIRCRAFT MAINTENANCE MONITORING USING TELEMETRY**

D. DOWLING and R. A. LANCASTER (ARINC Research Corp., Annapolis, MD) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 449-456.

The purpose of this paper is to present a concept utilizing digital telemetry links to upgrade the military aircraft maintenance approach in the future. The evolution of digital avionics in both military and commercial aircraft is creating changes that affect today's approach to maintenance. Commercial aviation has made significant progress in the direction of maintenance monitoring using a digital telemetry link. This paper presents the status of maintenance-monitoring efforts within the commercial airlines and, recognizing the differences that exist between the military and commercial application, proposes an aircraft maintenance concept for the military in the 1990s. Author

**A86-27819**

**FREQUENCY SYNTHESIS TYPE AIRBORNE TRANSMITTERS**

W. MARTINI (Intertechnique, S.A., Departement Telemesures et Systemes, Les Ulis, France) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 575-585.

Two basic schemes for a frequency modulation type airborne telemetering transmitter are examined: a transmitter with transposition through mixing and filtering and a transmitter with phased-in servoing of the carrier to a reference after frequency division. The schemes are studied in terms of the ability to accept high base bands and the possibility of frequency synthesis that they offer. The reasons for the choice of one of these schemes and the resulting market reception in France are explained. Technical difficulties arising from the concept of a frequency synthesis transmitter are discussed. C.D.

**A86-27829#**

**A PROCEDURE FOR THE EVALUATION AND ANALYSIS OF THE OPERATIONAL PRACTICABILITY AND EFFECTIVENESS OF AUTOMATED TRAFFIC FLOW CONTROL PROCEDURES FOR THE NEAR TERMINAL AREA [EIN VERFAHREN ZUR BEWERTUNG UND ANALYSE DER OPERATIONELLEN PRAKTIKABILITAET AUTOMATISIERTER VERKEHRSFLUSSSTEUERUNGSVERFAHREN FUER DEN FLUGHAFENNAHBEREICH]**

A. HOERMANN Berlin, Technische Universitaet, Fachbereich Verkehrswesen, Dr.-Ing. Dissertation, 1985, 215 p. In German. refs

The continuously increasing air traffic volume makes it necessary to enhance the capacity of the airports. The main aim of the present study is related to the development of criteria for an objective evaluation of competing automated flight management and air traffic control concepts in the Terminal Maneuvering Area (TMA), taking into account also an assessment of the effects of technological and/or operational modifications of system components. Details regarding the air traffic flow control in the TMA are discussed, giving attention to manual control in the near terminal area, the principles and algorithms of the control techniques, and the employment of automated control procedures. The Variable Path Speed Control (VPSC) procedure and the Fixed Path Speed Control (FPSC) procedure are examined. A simulation model is considered along with the program system TASIMD (Terminal area simulation program considering the aircraft dynamics), the derivation of a quality functional for a relative evaluation of the considered automated procedures and the results of an air traffic simulation. G.R.

**A86-27849**

**THE USE OF MICROCOMPUTERS IN INERTIAL NAVIGATION SYSTEMS WITH STRAPDOWN SENSORS AND FOR MEASUREMENT SYSTEMS OF AVERAGE ACCURACY [EIN BEITRAG ZUM EINSATZ VON MIKRORECHNERN IN TRAEGHEITSNAVIGATIONSSYSTEMEN MIT FAHRZEUGFESTEN SENSOREN UND ZUR STUETZUNG VON MESS-SYSTEMEN MITTLERER GENAUIGKEIT]**

C. DEHN Braunschweig, Technische Universitaet, Fakultaet fuer Maschinenbau und Elektrotechnik, Dr.-Ing. Dissertation, 1983, 156 p. In German. refs

A navigational computer composed of three microcomputers has been developed, and its practical application in flight tests is reported. This computer is distinguished from inertial units by its flexibility and modular program configuration. Procedures for improving accuracy in position determination are discussed. C.D.

**A86-27852#**

**FLIGHT MECHANICS CONTRIBUTIONS TO THE TIME-BASED TRAJECTORY CONTROL IN THE AIRCRAFT LONGITUDINAL PLANE [FLUGMECHANISCHE BEITRAEGE ZUR ZEITBEZOGENEN BAHNFUEHRUNG IN DER FLUGZEUGLAENGSEBENE]**

R. LUCKNER Braunschweig, Technische Universitaet, Fakultaet fuer Maschinenbau und Elektrotechnik, Dr.-Ing. Dissertation, 1984, 196 p. In German. refs

The continuously increasing volume of air traffic requires an enhancement of the capacity of air traffic systems. In this context, a transition is required from the air traffic systems of the third generation to the new systems of the fourth generation, which are distinguished by an extension of automation and subsystem integration. The present study is concerned with one vital aspect of the considered transition, taking into account the ability of future aircraft to fly along trajectories which are provided with respect to the path and the time at which a given point on this path has to be occupied by the aircraft (4-D navigation). An investigation is conducted regarding the phenomena of flight mechanics which arise in connection with the new requirements. It will be necessary to stabilize the aircraft with the aid of a position controller. Attention is given to the characteristics of time-based trajectory control, a mathematical model representing the involved problems, the compensation for errors regarding horizontal speed and position, positional control, and a simple control system. G.R.

**A86-27898**

**A NEW SYSTEM SIMULTANEOUSLY COVERING EN ROUTE NAVIGATION AND LANDING [UN NOUVEAU SYSTEME COUVRANT, A LA FOIS, LA NAVIGATION 'EN ROUTE' ET L'ATTERRISSAGE]**

M. SCHILLIGER (LMT Radio Professionnelle, Boulogne-Billancourt, France) Navigation (Paris) (ISSN 0028-1530), vol. 34, Jan. 1986, p. 15-27. In French.

The proposed system, derived from the standard TACAN, is suited for both civil and military applications. The ground beacon operates normally to perform the navigation function, but also transmits additional information needed for landing. On board, the received signals are processed together with the altitude information, and the result is displayed for the pilot on the navigation and ILS indicators. The extra data transmitted can cover several airfields in the vicinity of the ground beacon. Test results obtained with the Nord-260 aircraft and the SA-330 Puma helicopter are summarized. B.J.

**A86-27899**

**FLIGHT TESTS OF MLS ELEVATION GUIDANCE [ESSAIS EN VOL DU GUIDAGE EN SITE DU MLS]**

K. KOREMURA and T. KATANO (Ministry of Transport, Electronic Navigation Research Institute, Tokyo, Japan) Navigation (Paris) (ISSN 0028-1530), vol. 34, Jan. 1986, p. 63-72. In French.

The accuracy of the MLS elevation guidance subsystem is degraded owing to reflection and diffraction in the vicinity of the MLS antennas. This paper describes flight-test studies of these effects carried out by the Japanese Electronic Navigation Research Institute at Sendai Airport; the tests involved the use of an aircraft equipped with an MLS receiver, a telemetry system, and a TV tracking system. The results indicate that, even when the equipment is sited very unfavorably with respect to nearby buildings, a high guidance accuracy can be achieved if the approach is made along the median line; the accuracy is equal to one-third of the value defined by the SARP for the angle guidance ground subsystems of the MLS. B.J.

**A86-27900**

**ERRARE HUMANUM EST . . . SED PERSEVERARE DIABOLICUM OR NAVIGATION ERRORS OF THE 747 AND THE 'HEADING' POSITION [ERRARE HUMANUM EST . . . SED PERSEVERARE DIABOLICUM OU LES ERREURS DE NAVIGATION DU 747 ET LA POSITION 'HEADING']**

J. FOURNIER Navigation (Paris) (ISSN 0028-1530), vol. 34, Jan. 1986, p. 92-94. In French.

Navigation errors due to a selector located on the front panel of the Boeing 747 cockpit are examined with reference to Flight JL-441 (Tokyo-Paris via Moscow) which strayed off course near Sakhalin on October 30, 1985. It is suggested that a flashing alarm system can reduce these errors. B.J.

**A86-28311**

**A COMBINED OPTIMAL ALGORITHM FOR FILTERING AND CALCULATING NAVIGATION COORDINATES [OB'EDINENNYI OPTIMAL'NYI ALGORITM FIL'TRATSII I SCHISLENIIA NAVIGATSIONNYKH KOORDINAT]**

O. A. BABICH IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 71-82. In Russian.

The problem of filtering signals from the on-board transducers is formulated mathematically for the case of an excess number of measured parameters. A mathematical model of the errors of an inertial navigation system is examined, and coupling equations are presented. An analysis is also made of the errors of the on-board ranging system. A discrete-continuous algorithm for filtering and calculating coordinates is proposed which involves integrating eleventh-order differential equations and is almost as accurate as a full continuous algorithm. V.L.

**A86-28312**

**RELIABILITY OF AIRCRAFT NAVIGATION [NADEZHNOST' NAVIGATSII LETATEL'NYKH APPARATOV]**

A. A. KRASOVSKII IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 82-97. In Russian. refs

Navigation methods and the structure of navigational complexes are briefly reviewed, and an assessment is made of the reliability with which certain requirements for flight paths in real two- and three-dimensional space are satisfied and the time of arrival at specified navigation points is determined. The reliability of navigation is evaluated analyzing probabilities for a given set of events and determining the current probability density in the navigation coordinate space. V.L.

**A86-28326**

**NAECON 1985; PROCEEDINGS OF THE NATIONAL AEROSPACE AND ELECTRONICS CONFERENCE, DAYTON, OH, MAY 20-24, 1985. VOLUMES 1 & 2**

Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1985. Vol. 1, 917 p.; vol. 2, 809 p. For individual items see A86-28327 to A86-28517.

Among the topics discussed are: signal processing; airborne computers and voice communications; and data transmission and fiber optics. Consideration is also given to: advanced computer architecture and hardware; airborne image processing; target recognition acquisition systems; and navigation systems. Additional topics discussed include: weapons guidance and interface; Kalman filtering methods; flight control design techniques; and software development and management for military aviation. I.H.

**A86-28335**

**A NOVEL VOICE ACTIVATED SWITCH (VOX) FOR HIGH NOISE ENVIRONMENTS**

R. VEMULA, E. LEE, and G. BOUKIS (Telephonics Corp., Huntington, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 56-60.

A newly developed VOX circuit for detecting the speech characteristics of the cockpit noise background is described. The circuit consists of a 12-bit A/D converter which collects signal samples at a rate of 2500 samples per second. The A/D converter is clocked by counters which provide an appropriate clock rate for feeding the samples into a microprocessor. Before the signal is supplied to the converter, it is lowpass filtered to about 800 Hz. Timing measurements show that only 20 percent of the processor time is used to implement the circuit. An example of a speech waveform which was detected by the VOX circuit during performance tests is given in graphic form and a schematic diagram of the VOX circuit is provided. I.H.

**A86-28337**

**A DISTRIBUTED, FAULT-TOLERANT IMPLEMENTATION OF THE AIRBORNE DIGITAL MAP USING VLSI COMMON PROGRAMMABLE MODULES**

J. C. WAHTERA, J. B. PEARCE (Harris Corp., Melbourne, FL), O. M. CROMER, and S. S. SINOR (Westinghouse Electric Corp., Baltimore, MD) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 70-77. refs

The Digital Map Generator (DMG) provides an aircraft pilot with a full-color, planar map display for nap-of-the-earth flight. It also provides a digital terrain data base for use in advanced avionics functions such as terrain correlation and autonomous navigation. The DMG has been configured as a group of custom dedicated hardware processors implemented in conventional digital integrated circuits. As advanced aircraft are developed, requiring expanded capability and flexibility of digital map functions, advanced DMG architectures also must be developed. These architectures would be fault-tolerant, fully-integrated subsystems of general-purpose multiprocessors. This paper presents an advanced DMG architecture that implements the map functions in VLSI common programmable modules. The map function software is distributed among the processing modules, and execution is controlled by utilizing dynamic task allocation. Commonality of hardware and dynamic reassignment of tasks allows fault-tolerant techniques to be implemented and facilitates integration of other avionics functions within the same multiprocessor system. Author

**A86-28356**

**NAVIGATION METHODOLOGY - AN INVESTIGATION OF AN INERTIAL NAVIGATION SYSTEM (INS) ENHANCEMENT**

S. B. RICHTER and D. M. PARRY (Aydin Corp., Horsham, PA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 223-230. refs

To date, the utility of stored map data is proportional to the accuracy with which the aircraft's position is known. Inertial Navigation Systems (INS) rely heavily upon numerical integration techniques in order to locate the 'relative' position of aircraft and their associated targets. Current INS systems use the spherical modeling system. The INS subsystem at AYDIN is based upon the biaxial ellipsoidal system. Thus the accuracy with which the time and position requirements for certain mission-critical points are satisfied is dependent on the modeling system chosen. Author

**A86-28357**

**DESIGN TECHNIQUES FOR IMPROVED MAP-AIDED NAVIGATION**

C. A. BAIRD (Harris Corp., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 231-238. refs

This paper presents techniques to effectively combine elevation and derived slope data from digital terrain elevation maps to improve the navigation accuracy of map-aided navigation systems. Elevation correlation processing is used to provide position fixes, signal-to-noise ratio estimates, and acquisition information. The details of this processing are examined using both analytical results and simulations. A modified Kalman filter is used to combine these position fixes with the navigator's position estimates, as well as provide updates using the derived slope data. The accuracy of the filter's error covariance estimates is emphasized. Throughout this work, simulations based on statistical map and error models, DMA maps, and flight test data are used for system design and evaluation. Tracking mode behavior is emphasized, but the difficult problem of acquisition from large position uncertainties is also addressed. Author

**A86-28358#**

**MICROWAVE LANDING SYSTEM**

T. E. EVANS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 239-243.

The National Microwave Landing System (MLS) program is a joint DOT/DOD/NASA effort to implement a common civil/military precision landing system to replace the current Instrument Landing System (ILS). The MLS will be capable of providing precision landing guidance down to Category III minimum while allowing for complex approach paths in both the horizontal and vertical planes. The system is based on the Time Reference Scanning Beam (TRSB) technique which was selected by the International Civil Aviation Organization (ICAO) in April 1978 as the new international landing system standard. MLS is less susceptible to interference from the surrounding area and provides a greater signal coverage area than ILS. Author

**A86-28360**

**DESIGN CONSIDERATIONS FOR DOPPLER VOR GROUND STATION ANTENNA ARRANGEMENT**

M. C. CHANDRA MOULY, S. SURENDER, C. DAMODARA RAO (VR Siddhartha Engineering College, Vijayawada, India), and G. VIJAY PRASAD (KL College of Engineering, Vijayawada, India) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 252-259. refs

Commonality of the airborne receiver for both VHF Omni Range (VOR) and Doppler VOR (DVOR) ground transmissions enforces certain restrictions on the DVOR signal format. This paper elucidates these restrictions and brings out the elegance of the DVOR system with respect to the terrain problems. Analytical methods to determine the number of Alford loops have been developed. Nyquist's sampling theorem has been employed for the evaluation of the minimum number. This work provides analytical support for the design of the DVOR ground station antenna arrangement. Author

**A86-28361**

**CONCEPT AND PERFORMANCE ANALYSIS OF A STRAPDOWN NORTHFINDER**

U. K. KROGMANN (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, West Germany) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 260-267.

To determine the north direction with a strapdown northfinder, two components of the earth rate are measured with a dynamically tuned rotor gyro. This simple principle involves the problem that gyro errors and angular disturbances corrupt the useful sensor information. The effect of non-random time-varying drifts can be excluded by measuring the earth rate in different positions of the gyro with respect to the earth. A theoretically dynamic exact method for large angular disturbance rejection is derived and analyzed. It requires the incorporation of two inertial grade tilt - or acceleration-sensors and is based on the definition of an analytic virtual plane. By levelling this virtual plane the northfinder is exposed to an analytic fine leveling. Undisturbed rates signals are amenable within the virtual level loops for an accurate determination of the north direction. Author

**A86-28369**

### JTIDS RELNAV PERFORMANCE EVALUATION

M. S. MURPHY (VERAC, Inc., San Diego, CA) and J. LINDEGREN (USAF, Eglin AFB, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 343-350.

The Joint Tactical Information Distribution System (JTIDS) Test Data Optimal Processor (JTIDS TDOP) has been developed, as a tool for the postflight assessment and error allocation of the JTIDS relative navigation (RELNAV) function, which is scheduled for testing during 1985/1986. The JTIDS TDOP utilizes advanced numerical techniques to implement an extended Kalman filter-based navigation smoothing algorithm, which integrates test data from JTIDS, INS, and test-range tracking instrument sources. The Optimal Processor will create accurate trajectory estimates, assess JTIDS RELNAV compliance to accuracy requirements, and analyze actual navigation errors into the contributing causes, thus providing a tool for DT&E test planning. The performance expected from the JTIDS TDOP system was tested on a simulated three-aircraft scenario. I.S.

**A86-28370**

### AN ADAPTIVE UD-FACTORIZED KALMAN FILTER FOR REAL-TIME TACTICAL AIRCRAFT TRACK-WHILE-SCAN SYSTEMS

R. M. YANNONE (General Electric Co., Utica, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 358-363. refs

The application of an adaptive extended Kalman Filter (EKF) is described for removing divergence problems encountered by the use of Kalman filters in treating the kinematic data obtained in the track-while-scan radar mode. The eigenvector analysis used to examine the inherent discrete-time stability behavior of the Kalman filter is discussed, showing the filter stability to be a function of the state transition, Kalman gain, and measurement transformation matrices. An EKF, implemented by the UD factorization algorithm for gain and error covariance updates, was found to be part of the solution. The second part of the solution was to use sequential relinearization and an adaptive thresholding mechanism for selecting the process noise covariance matrix based on the range and the range rate measurement residuals. I.S.

**A86-28385**

### AUTONOMOUS LANDING GUIDANCE SYSTEMS

E. F. ROY (Kaiser Aerospace and Electronics Corp., Kaiser Electronics Div., San Jose, CA) and J. W. DAVISON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 490-497. refs

The selection of the proper components for autonomous landing guidance systems for low visibility recovery of aircraft to battle damaged and repaired airfields is examined. The use of forward-looking infrared (FLIR) sensors with high resolution radar and flight guidance symbology instead of the instrument landing system is analyzed. The application of specific sensors is limited by the technical properties of the sensor, the effect of the atmosphere on the electromagnetic waveband of the sensor, and the characteristics of the scene. The capabilities and restrictions of active sensors such as pencil beam radar and side-looking airborne radar, and passive sensors such as FLIR and millimeter wave FLIR are described. The sensors performance during various weather conditions are evaluated. The incorporation of image processing techniques into the automomous landing guidance system for enhancement and integration of the data is discussed. A study of the image processing techniques reveals that median filter is the best method for noise removal and unsharp masking produces edge enhancement, resolution improvement, and contrast enhancement. I.F.

**A86-28389**

### DEMONSTRATION OF AN INNOVATIVE TECHNIQUE FOR TERRAIN FOLLOWING/TERRAIN AVOIDANCE - THE DYNAPATH ALGORITHM

R. V. DENTON, J. E. JONES, and P. L. FROEBERG (TAU Corp., Los Gatos, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 522-529. refs
(Contract F33615-83-C-3617)

Automated low-altitude maneuvering flight requires a Terrain Following/Terrain Avoidance capability as a central building block to exploit terrain masking while simultaneously assuring safe flight. This paper presents a new TF/TA optimization approach - the Dynapath Algorithm - to efficiently generate an optimum real-time TF/TA trajectory. It has been designed to be compatible with emerging programs that include terrain-masked threat avoidance as well. The optimization technique as described here is based on a dynamic programming approach that demonstrates how high-resolution and efficient coupling to the flight control system can be obtained. Preliminary computer results are provided to show how the approach results in tactically meaningful TF/TA trajectories. Author

**A86-28391**

### A COMPARISON OF DIGITAL TERRAIN MODELS AND TERRAIN MASKING ALGORITHMS

B. E. GINDELBERGER and F. J. STEENROD (BDM Corp., McLean, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 538-542.

Programs used for simulating scenarios involving aircraft and ground sites frequently need some type of terrain model and an algorithm to determine when masking occurs between two points. This paper describes three different terrain models and compares them. Each model was implemented on the same computer and several trials using identical flight paths were executed to derive these results. The comparison shows (1) how closely the different models match the results of each other, (2) the efficiency of each model in terms of processing time, and (3) the size of data files necessary to represent a region of terrain for each model. Author

**A86-28443**

### A SPEECH RECOGNITION RESEARCH TOOL FOR THE C-130 HERCULES

C. M. BREEVOORT (Lockheed-Georgia Co., Electronics Research and Development, Marietta, GA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 966-969.

Ongoing efforts aimed at providing flexible and reconfigurable research tools for speech recognition, particularly to assist aircraft flight crews, are discussed. The primary advantage for such a system is that a vocal exchange permits pilots to receive information and operate systems while continuing to use their eyes and hands for more critical tasks. Issues examined include: flexibility for the human factors engineer; flexibility for the digital signal processing engineer; and a user-programmable speech recognizer. Much work remains to be done in software development before one can claim 'better than 99 percent' accuracy with the speech recognizer in the cockpit environment aboard the Hercules test-bed aircraft. D.H.

**A86-28447**

**A SPEECH PROCESSING SYSTEM FOR AN AIR TRAFFIC CONTROL RADAR SIMULATOR**

R. LAWSON (Gould, Inc., Simulation Systems Div., Melville, NY) and J. DAMOULAKIS (Gould Research Laboratories, Rolling Meadow, IL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 987-989.

A proposed speech control system to replace Track Control Consoles or TCCs (for an air-traffic-control radar simulator) ordinarily operated by pseudo pilots is described. Such Track Control Consoles are manned by personnel who perform the boring task of altering the tracks of simulated aircraft by entering keyboard data in response to the commands from the trainee controller. A speaker-dependent voice recognition system is substituted for the track altering function of each TCC, while a voice synthesis system is substituted for the pilot acknowledgment function. An interface is then created which allows the TCCs to remain in the loop and assume dual aircraft control, should the need arise. A software control system is utilized which permits the rapid movement of voice data from mass storage (on floppy and hard disks) to allow for operation with the required vocabulary. In addition, the relationship between the air traffic control vocabulary and memory requirements is shown, as is the architecture of the proposed system. Finally, the savings in person hours is projected over a typical training scenario for one year of operation. D.H.

**A86-28470#**

**THE EFFECTS OF ATMOSPHERIC TURBULENCE ON AN AIR-TO-AIR OPTICAL COMMUNICATION LINK**

J. N. KANAVOS (USAF, Foreign Technology Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1174-1182. refs

An analysis is presented of the performance of an optical communications link between aircraft, evaluating the effect of atmospheric turbulence on bit error rate. It is assumed that a direct detection scheme is used with pulse code modulation of the on/off keying type; the optical beam has plane wave characteristics; the optical beam is assumed to be at constant altitude; and the atmosphere is assumed to be moving rather than the aircraft. Statistical techniques are used to describe the time-varying intensity fluctuations. Important quantities are: the probability distribution of the intensity fluctuations, the refractive index structure constant, and the intensity fluctuation power spectral density. It is found that an appropriate choice of altitude level could minimize a link's bit error rate while maximizing its reliable communication range. D.H.

**A86-28473**

**THE DEVELOPMENT STATUS OF JTIDS DUAL MODE TDMA AND DISTRIBUTED TDMA (DTDMA) FULL SCALE DEVELOPMENT TERMINALS - AN UPDATE**

J RUBIN (ITT, ITT Avionics Div., Nutley, NJ) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1206-1214. refs

The successful transition of terminal development featuring the JTIDS (Joint Tactical Information Distribution System) DTDMA (Distributed Time Division Multiple Access) architecture, from the advanced development model phase to the full scale development model phase has been achieved. This next generation C-cubed/C-N-I architecture is claimed to offer the potential for significant improvements in system and terminal data rate capacity, jam resistance, security, reliability, flexibility and a reduced probability of enemy exploitation, at an affordable price. D.H.

**A86-29300**

**GPS AIDED INERTIAL NAVIGATION**

J. T. NIELSON, G. W. SWEARINGEN, and A. J. WITSMEER (Boeing Aerospace Co., Seattle, WA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, March 1986, p. 20-26.

The Global Positioning System is an extremely accurate satellite-based navigation system which, after its completion in 1989, will provide users worldwide, 24 hour, all weather coverage. A joint research project among Boeing, Rockwell-Collins, and Northrop has been completed in which a GPS receiver was integrated with a low-cost strap-down inertial navigation system and a flight computer. A Kalman filter in the latter allows in-flight alignment and calibration of the INS. In addition, feedback from the INS to the GPS receiver improves the system's ability to reacquire satellite signals after outages. The resulting system combines the accuracy of GPS with the jamming immunity and autonomy of inertial navigation. System tests were conducted in which a Boeing owned T-33 jet aircraft was flown through known test patterns to align and calibrate the INS. Earlier tests, including test against an airborne jammer, were conducted in a modified passenger bus. Author

**A86-29578#**

**A SATELLITE SYSTEM FOR AERONAUTICAL DATA COMMUNICATIONS**

W. A. SANDRIN and D. W. LIPKE (COMSAT, Clarksburg, MD) IN: Communication Satellite Systems Conference, 11th, San Diego, CA, March 17-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 12-17. COMSAT-sponsored research.
(AIAA PAPER 86-0602)

A system is described that can provide data communications via satellite to transoceanic commercial aircraft. The system will provide both air traffic control and airline company communications data services, and will require only modest satellite capacity operating at L-band. If this capability can be provided by the INMARSAT space segment, cost benefits will be realized through the sharing of satellites and earth stations in the INMARSAT system. Attention is also given to designs which minimize aircraft equipment costs, in part by the use of low-gain, flush-mounted aircraft antennas. Low data rates are assumed (200 to 400 bit/s), using DPSK modulation and a rate 1/2 convolutional code with interleaved code symbols and soft-detection Viterbi decoding. This modulation/coding scheme was chosen to provide reliable operation in the multipath fading environment. A brief description of the recommended system is given, followed by a discussion of propagation, aircraft antenna, modulation and coding, acquisition and synchronization, and network design issues. Author

**A86-29783**

**DETECTION OF NON-MOVING TARGETS BY AIRBORNE MM-WAVE RADARS**

S. A. HOVANESSIAN (Hughes Aircraft Co., El Segundo, CA) Microwave Journal (ISSN 0026-2897), vol. 29, March 1986, p. 159, 160, 162 (3 ff.). refs

The mathematical relations involved in studying the conditions for the detection of a stationary ground target by airborne mm-wave radars are briefly examined, and questions of atmospheric attenuation are explored. For specified radar and target parameters, computer programs can be written to compute target, clutter, and rain backscattering S/N as a function of range, including atmospheric attenuation. Attention is given to numerical examples of stationary ground targets, numerical results, the detection of hovering helicopters against hilly background, and calculations regarding the detection ranges of hovering helicopters against hilly background. G.R.

**N86-20382** British Aerospace Dynamics Group, Bristol (England). Guidance and Control Dept.
**INTERPOLATION OF HEIGHTS AND SLOPES FROM A DIGITAL TERRAIN ELEVATION MODEL**
R. F. SCOTT May 1982 12 p
(BAE-BT-13198) Avail: Issuing Activity

An interpolation scheme for the TERPROM navigation system, that combines third order polynomials in the x and y directions to obtain a continuous surface which fits the terrain model exactly, conforming to whatever degree of intricacy the model can provide, is outlined. It is recommended that flights where deterioration occurred over rugged country are re-run with this interpolation to determine improvements in accuracy. Author (ESA)

**N86-20383#** Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
**EVALUATION OF THE FAA DESIGN PROCEDURES FOR HIGH TRAFFIC VOLUME PAVEMENTS Report, Jan. 1983 - May 1984**
S. D. KOHN Oct. 1985 144 p refs
(Contract DTFA01-81-Y-10555)
(DOT/FAA/PM-84/14) Avail: NTIS HC A07/MF A01

The results of a field study of the performance of high traffic volume airfield pavements is presented. Both rigid (portland cement concrete) and flexible (asphalt concrete) pavements were included in the study. Condition surveys and nondestructive testing were performed on the pavement sections in order to measure present performance and estimate load-carrying capacity. Traffic and material properties data were also collected for each pavement section. These parameters were used to compared thicknesses obtained using the current FAA design procedure and the thicknesses of the existing sections in order to evaluate the adequacy of the current design procedures. In general it was found that the design procedures are adequate; however, further field study has been recommended in order to verify collected data. Author

**N86-20384*#** Boeing Commercial Airplane Co., Seattle, Wash.
**PERFORMANCE OF A COMMERCIAL TRANSPORT UNDER TYPICAL MLS NOISE ENVIRONMENT Final Report**
J. K. HO Feb. 1986 55 p refs
(Contract NAS1-17635)
(NASA-CR-178032; NAS 1.26:178032; D6-57212) Avail: NTIS HC A04/MF A01 CSCL 17G

The performance of a 747-200 automatic flight control system (AFCS) subjected to typical Microwave Landing System (MLS) noise is discussed. The performance is then compared with the results from a previous study which had a B747 AFCS subjected to the MLS standards and recommended practices (SARPS) maximum allowable noise. A glide slope control run with Instrument Landing System (ILS) noise is also conducted. Finally, a linear covariance analysis is presented. Author

**N86-21531#** European Space Agency, Paris (France).
**ALGORITHMS FOR THE AUTOMATIC FOUR-DIMENSIONAL GUIDANCE OF AIRCRAFT, TAKING INTO ACCOUNT THE CURRENT WIND SITUATION**
W. LECHNER Oct. 1985 106 p refs Transl. into ENGLISH of "Algorithmen zur automatischen 4 dimensionalen Flugbahnfuehrung unter Beruecksichtigung der momentanen Windsituation" Rept. DFVLR-FB-84-40 Brunswick, West Germany, Sep. 1984
(ESA-TT-908; DFVLR-FB-84-40) Avail: NTIS HC A06/MF A01

An automatic time-of-arrival control flight mode covering the terminal maneuvering area was developed for the digital flight-control system of the HFB 320 test aircraft and flight tested. The algorithms used for computing four dimensional flight paths taking into account the current wind situation are described. Methods for measuring, filtering, and predicting the wind vector are developed and discussed with reference to the results of the flight tests. Evaluation shows that time error limits of + or - 5 sec can be achieved under varied wind situations. The aircraft-oriented method of wind prediction by extrapolation, based on the Kalman filter method, proves to be particularly efficient. Author (ESA)

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-26585**
**FLIGHT TESTING OF AN ASW HELICOPTER**
C. R. GUY and M. J. WILLIAMS (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 4, 1985, p. 317-330. refs

A programme of flight trials carried out with a Sea King Mk 50 anti-submarine warfare helicopter is described. An outline is given of the aircraft instrumentation, the data-acquisition system and the data-analysis procedures. Results are presented for conditions of trimmed level flight together with typical examples of dynamic response tests, transition manoevres and Doppler and cable hover tests. The flight trials programme was designed to provide results both for use in the validation of a mathematical model of the Sea King helicopter and for more general use in helicopter flight behaviour studies. Author

**A86-26587*** California Univ., Los Angeles.
**APPLICATION OF MODERN STRUCTURAL OPTIMIZATION TO VIBRATION REDUCTION IN ROTORCRAFT**
P. FRIEDMANN (California, University, Los Angeles) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 4, 1985, p. 363-376. refs
(Contract NAG2-226)

This paper explores a number of techniques which are capable of reducing vibration levels in rotorcraft by redistributing the mass and stiffness properties of the structure. First, vibration reduction in the rotor is considered by using formal structural optimization for ensuring optimal frequency placement. Two cases are considered: in the first case aeroelastic constraints are not enforced and the blade is designed for minimum weight; in the second case aeroelastic constraints are enforced and vibration levels are minimized in forward flight. Next, vibration reduction in the fuselage is considered and the various methods available for vibration reduction by local structural modification are reviewed. The feasibility of combining local structural modification with modern structural optimization is discussed and some extensions of previous research are suggested. Author

**A86-26647#**
**ELECTRO-IMPULSE DE-ICING OF AIRCRAFT ENGINE INLETS**
D. O. NELEPOVITZ and H. A. ROSENTHAL (Rohr Industries, Inc., Chula Vista, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.
(AIAA PAPER 86-0546)

The structure and mechanism of the electroimpulse deicing (EIDI) system are described; the technical advantages the system provides the aircraft are discussed. The wind tunnel testing of turbofan and turboprop inlets is examined; it is observed that the EIDI system is effective for the aircraft. The fatigue testing of the system for turbofan, turboprop, and high by-pass ratio engine inlets is proposed. I.F.

**A86-27654#**

**OPTIMAL DESIGN OF COMPOSITE POWER TRANSMISSION SHAFTING**

J. W. LIM and M. S. DARLOW (Rensselaer Polytechnic Institute, Troy, NY) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 13 p. refs

(Contract DAAG29-82-K-0093)

The replacement of a conventional drive shaft system with a composite drive shaft system with the same transmitted power is studied. As an illustration, the optimal design of a graphite/epoxy tail rotor drive shaft for the next generation of helicopters is considered. The background for the optimal design of a composite tail rotor and synchronization drive shafts is examined, taking into account torsional and lateral vibration. A computer algorithm for the optimal design of the drive shaft is discussed. The parameters of the optimized drive shaft are given and compared with conventional aluminum drive shaft values. It is shown that a composite shaft with a single tube operating supercritically at 6000 rpm can reduce the system weight by as much as 63.1 percent compared to the conventional shaft. The results of a parametric study of the composite shaft are reported, and trends of the optimal design of composite drive shafts are summarized. C.D.

**A86-27657#**

**ANALYSIS OF THE WING/ROTOR AND ROTOR/ROTOR INTERACTIONS PRESENT IN TILT-ROTOR AIRCRAFT**

D. R. CLARK (Analytical Methods, Inc., Redmond, WA) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 16 p. refs

An advanced configuration modeling program has been used to analyze the aerodynamics of a representative tilt-rotor/wing combination in both hover and (helicopter) forward flight. The program which combines a panel representation of the wing and a blade element model of the rotor system provides a fully coupled solution of the loads on both components. Results are presented for hover and forward flight conditions for isolated rotor, side-by-side rotors and rotor plus wing configurations and include integrated wing and rotor loads, detailed rotor blade loads and off-body flow field surveys showing the effect of rotor and wing flow in the region of possible tail locations. Author

**A86-27661*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**IDENTIFICATION AND VERIFICATION OF FREQUENCY-DOMAIN MODELS FOR XV-15 TILT-ROTOR AIRCRAFT DYNAMICS**

M. B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), J. G. M. LEUNG, and D. C. DUGAN (NASA, Ames Research Center, Moffett Field, CA) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 17 p. Previously announced in STAR as N84-34445. refs

Frequency-domain methods are used to extract the open-loop dynamics of the XV-14 tilt-rotor aircraft from flight test data for the cruise condition (V = 170 knots). The frequency responses are numerically fitted with transfer-function forms to identify equivalent model characteristics. The associated handling quality parameters meet or exceed Level 2, Category A, requirements for fixed-wing military aircraft. Step response matching is used to verify the time-domain fidelity of the transfer-function models for the cruise and hover flight conditions. The transient responses of the model and aircraft are in close agreement in all cases, except for the normal acceleration response to elevator deflection in cruise. This discrepancy is probably due to the unmodeled rotor rpm dynamics. The utility of the frequency-domain approach for dynamics identification and analysis is clearly demonstrated. Author

**A86-27663#**

**STRUCTURAL DYNAMIC ASPECTS OF ROTOR ANTIRESONANT ISOLATION**

J. STOPPEL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 9 p.

The efficiency of the nodal isolation system ARIS based on special antiresonance isolator elements is theoretically and experimentally confirmed using the BK 117 helicopter. It is demonstrated that, when a natural frequency and the antiresonance frequency coincide, the isolator compensates the resonance. This zero compensation in the undamped system can impair the isolating effect for a real damped structure with many modes close to the 4/rev range. The use of finite element methods for eigenvalue analysis and frequency response can be used to predict vibration problems and perform needed modifications. C.D.

**A86-27820**

**ROTATING AERODYNAMIC EXCITERS FOR IN-FLIGHT FLUTTER TESTING**

M. PENNACHIONI (Centre d'Essais en Vol, Base d'Essais, Istres, France) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 587-601.

Structural excitation as observed in-flight flutter testing is considered along with the principles of the 'Colibri' exciters, the design of an in-flight excitation system, aspects of model building, and preliminary tests. Two Colibri units were built, including a low-power unit designed to validate the method by the in-flight testing of a light aircraft, and a medium-power units for an actual test on a large military transport aircraft modified by the installation of pods under its wings. It is found that using the rotating fin method to define an aerodynamic structural exciter leads to an answer which can be usefully combined with existing methods. This principle can be used to design and produce a family of exciters with forces in the range from a few Nextons to a few hundred Nextons. G.R.

**A86-28060**

**ATR42 - FIRST OF A FAMILY**

D. LEARMOUNT Flight International (ISSN 0015-3710), vol. 129, Feb. 15, 1986, p. 24-29.

The design of Aerospatiale/Aeritalia's simple low-production-cost ATR42 regional airliner is described with efficiency achieved through advanced wing desig and lightness of the aircraft. There is extensive use of composite materials and the cockpit design features flightdeck controls that include a CRT display electronic flight instrument system, an electronic attitude director indicator, an electronic horizontal situation indicator, and a flight computer which controls the standard issue autopilot. Decisions to apply new technology, as well as the selection of more conventional features such as a mechanical control system, were based on simplicity in installation and maintenance, and cost effectiveness. To achieve quietness in the cabin the engines are mounted as far out on the wings as asymmetric engine control would allow, resulting in an unusually large vertical unit design. The aircraft is powered by two PW120 turboprops rated at 18 shp and has a maximum speed of 268 kt. R.R.

**A86-28093**

**LIGHT AIRCRAFT - THE WAY AHEAD IN DESIGN AND OPERATION; PROCEEDINGS OF THE SYMPOSIUM, LOUGHBOROUGH, ENGLAND, MARCH 31, APRIL 1, 1984**

Symposium sponsored by the Royal Aeronautical Society and Loughborough University of Technology. London, Royal Aeronautical Society, 1984, 217 p. No individual items are abstracted in this volume.

The present symposium on contemporary design practices in small general aviation and ultralight aircraft gives attention to guidelines for the scaling and integration of structural and component system features. Among the topics discussed are representative new designs for these classes of aircraft (such as inflatable airframe structures and motor-powered parachutes), the performance characteristics of two- and three-surface unconventional configurations, and a parametric study of light twin-engined aircraft. Also treated are light aircraft manufacture, including home-building with composite materials, as well as modern aircraft engine components, cockpit design, and low cost operation of light aircraft. O.C.

**A86-28281**

**HELICOPTER AIRWORTHINESS SYMPOSIUM, 19TH, LONDON, ENGLAND, DECEMBER 19, 1984, PROCEEDINGS**

Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1985, 149 p. No individual items are abstracted in this volume.

Various papers on helicopter airworthiness are presented. The topics addressed include: helicopter structural integrity in relation to airworthiness, strategy for the fatigue substantiation of helicopter dynamic components, monitoring of rotorcraft dynamic systems, and health and usage monitoring system developments in helicopters. Also discussed are: flight aspects, mechanical component health monitoring, crashworthiness of helicopters, and the W30-300 and compliance with HARP. C.D.

**A86-28310**

**OPTIMUM MAINTENANCE OF AIRCRAFT SYSTEMS ON THE BASIS OF THEIR CONDITION WITH ALLOWANCE FOR MEASUREMENT ERRORS [OPTIMAL'NAIA EKSPLUATATSIIA AVIATSIONNYKH SISTEM PO SOSTOIANIIU S UCHETOM OSHIBOK IZMERENIIA]**

M. S. IARLYKOV and E. IU. BARZILOVICH IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 62-70. In Russian. refs

The problem of optimum maintenance of aircraft systems on the basis of their actual condition is examined with emphasis on optimal nonlinear filtering of processes based on Markov's theory. In the statement of the problem, the parameters determining the technical condition of a system are represented by components of multidimensional Markovian diffusion processes. An example is presented illustrating the application of the approach proposed here to the maintenance of radio electronic systems. V.L.

**A86-28320**

**CHARACTERISTICS OF THE EFFECT OF THE POWERPLANT JET STREAMS ON THE DESIGN OF VTOL AIRCRAFT [OSOBENNOSTI VOZDEISTVIIA REAKTIVNYKH POTOKOV SILOVYKH USTANOVOK NA KONSTRUKTSIIU SAMOLETA VERTIKAL'NOGO VZLETA I POSADKI]**

V. V. NOVITSKII and V. F. PAVLENKO IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 245-252. In Russian. refs

The effect of the jet streams from the powerplants and of the turbulent vortexes formed as a result of separated flow past the aircraft nose and superstructure on the design of VTOL aircraft is analyzed using the formalism of random functions. Expressions are obtained for calculating the life of structural elements with allowance for the effect of jets and turbulent vortexes. V.L.

**A86-28397**

**ELECTROMECHANICAL ACTUATION RELIABILITY AND SURVIVABILITY**

K. A. HAIR (Grumman Aerospace Corp., Bethpage, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 596-603. refs

The level of fault tolerance, desired failure characteristics, and post failure performance of electromechanical actuation systems (EMASs) are evaluated. The designing of EMASs to specific levels of performance is discussed. The features of EMASs which improve reliability and survivability include the multimotor configuration, active isolation of a failure channel with breaks or clutches, and the ability to remotely mount the components; however, the need for redundancy due to the gearbox causes an increase in the weight and size of the actuators. Failure mode effects and criticality analysis were performed on an EMAS and an electrohydraulic actuator (EHA) for the F-14 aircraft. The data reveal that the EHA design has less failure modes and is therefore more reliable; however, the EMAS has a 49 percent probability of a kill compared to 76 percent for the EHA displaying the greater survivability of the EMAS. I.F.

**A86-28398**

**ELECTRONICS FOR ADVANCED ELECTROMECHANICAL ACTUATORS DESIGN CONSIDERATIONS**

M. B. MCCORMICK (Kollmorgen Corp., Inland Motor Div., Radford, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 604-610.

The design process for an electronic controller for an electromechanical actuator (EMA) is studied. Controller specifications and general system specifications for an EMA system are described. The formation of a functional block diagram, and the breadboarding and testing of the individual functional blocks are examined. The need for good communication with the customer in order to produce the desired final product is discussed. I.F.

**A86-28400**

**DIGITAL FAULT TOLERANT FLIGHT ACTUATION SYSTEMS**

H. H. BELMONT (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 618-627.

(Contract F33615-80-C-3623; AF PROJECT 2403)

A study was made of the equipments making up a typical flight control actuation system (servo electronics, servo valves, actuators and transducers) to determine where digital technology could replace analog technology for the purpose of providing a more fault-tolerant flight control actuation system. The investigation led to an evaluation of architectural design issues such as where to locate the servo electronics, the adequacy of military standard serial bus systems for control (versus data) applications, and the feasibility of providing electronics which could survive severe environments. Several actuation system configurations were evaluated which led to recommending, as the best developmental prospect, a concept of a locally integrated actuation system consisting of servo electronics, servo valves, actuators and transducers, interfacing with a digital flight control computer over a serial bus. Author

**A86-28402**

### A SURVIVABLE FLY-BY-WIRE SPOILER ACTUATION SYSTEM FEATURING NONFLAMMABLE FLUID, 8,000 PSI HYDRAULICS AND DIRECT DRIVE VALVES

R. WHITAKER, A. HARMON (Lockheed-Georgia Co., Marietta), and L. HAYNES (E-Systems, Inc., Montek Div., Salt Lake City, UT) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 633-640. refs

The occurrence of a total of 90 hydraulic fluid fire mishaps during the time from 1970 through 1975 has demonstrated the need to reduce the susceptibility of USAF aircraft to hydraulic fluid related fires. The most significant progress toward such a reduction is currently related to the development of a truly nonflammable hydraulic fluid, CTFE (AO2). Problems arise, however, in connection with the higher mass density of the new fluid. In an attempt to overcome these problems, a joint development program is conducted by two American aerospace companies. The program has the objective to produce an advanced, fireproof, survivable, spoiler actuation system for critical in-flight testing in a High Technology Test Bed (HTTB) aircraft in early 1986. In a system description, attention is given to a roll control system, hydraulic systems, the spoiler servoactuation system, design requirements, and a servoactuator. G.R.

**A86-28405**

### AN EXPERT SYSTEM FOR INTEGRATED AIRCRAFT/ENGINE CONTROLS DESIGN

J. H. TAYLOR (General Electric Co., Control Technology Branch, Schenectady, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 661-669. refs

In this paper, we discuss the concepts, requirements and architecture for an expert system for integrated aircraft/engine control systems analysis and design. The purpose of this concept is to provide a high-level environment embodying expertise from the many fields that enter into integrated flight and engine controls design (aerodynamics, structures, propulsion, pilot/aircraft interaction, mission performance requirements, control system design and validation), thereby facilitating the design of integrated aircraft control systems and ensuring that the best possible designs are obtained. The expert system concept also has capabilities to handle data-base management, and to take maximum advantage of existing conventional software. A prototype expert system has been implemented that demonstrates many of the capabilities and benefits of such an environment. A record of a hypothetical controls system modeling, analysis, and design session is included in this paper. Author

**A86-28454#**

### ARMY 21 - AVIATION

C. A. FRY (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1046-1049. refs

An Army perspective is presented for the 'ideal' Army helicopter cockpit of the future. The tactical necessities which drive cockpit design are reviewed. Aircrew functions, communications, secondary systems, mission execution and general configuration are discussed with regard to the helicopter that will be needed in the 2010 time frame. Artificial intelligence technologies as well as sensors and display systems will be key elements. D.H.

**A86-28455#**

### 2010 - THE SYMBIONIC COCKPIT

J. M. REISING and R. W. MOSS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1050-1054. refs

The cockpit of the year 2010 is described in terms of both the capabilities and systems it contains and how the pilot interacts with it. A brief mission narrative is provided describing several hours in the life of the Manta air superiority fighter. This is followed by a discussion of the [illegible] interface components employed in the cockpit including [illegible] voice, instrument panel display, canopy display, and holographic display systems. The concept of a 'symbionic' system is then introduced, describing in some detail the capabilities and features of a cockpit system that senses the physiological and mental state of the pilot and responds accordingly. Finally, conclusions and predictions are made that summarize and emphasize the points made in the paper. Author

**A86-28485**

### UNIFIED EM TRANSIENT PROTECTION REQUIREMENTS FOR AIRCRAFT AVIONICS LINE REPLACEABLE UNITS

G. W. KETTERLING (Boeing Military Airplane Co., Seattle, WA), R. C. VOGEL, and S. M. BRIGGS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1310-1319. refs

Unified test requirements and procedures are suggested to achieve a specified inherent transient protection level to transients originating from lightning, NEMP (nuclear electromagnetic pulses), and intrasystems transients. The procedures presented provide a minimum set of test requirements, methods, and procedures that can be utilized to achieve a reasonable and attainable level of equipment inherent protection based on actual test results. Threat environments and transient frequencies dealt with under the procedures are indicated. D.H.

**A86-28514**

### LIGHTNING SIMULATION TESTS ON A GRAPHITE/EPOXY AIRPLANE MOCKUP

D. B. WALEN (Boeing Military Airplane Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1570-1575.
(Contract F33615-82-C-3406)

Two test techniques to characterize aircraft and circuit responses to lightning environments were demonstrated on a graphite/epoxy F-16 mockup and the results are presented in this paper. Low-level swept-frequency transfer functions were measured using computer-controlled network analyzers. These frequency domain measurements required low drive current levels typically less than one ampere. Moderate level current pulse responses were measured using a crowbarred marx generator. The drive current exceeded 20 kA with a 4 x 10 to the 10th A/s peak rate of rise. The test technique demonstration showed that both low level swept-frequency transfer function measurements and moderate level current pulse tests can be used to simulate aircraft responses to lightning environments. Author

**A86-28559*#**

### THE JOINED WING - AN OVERVIEW

J. WOLKOVITCH (ACA Industries, Inc., Torrance, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 161-178. Previously cited in issue 07, p. 853, Accession no. A85-19626. refs
(Contract NAS2-11255; NAS2-11725; N00014-79-C-0953; N00014-82-C-0607)

**A86-28562*#** Colorado Univ., Boulder.
**NUMERICAL OPTIMIZATION DESIGN OF ADVANCED TRANSONIC WING CONFIGURATIONS**
G. B. COSENTINO (Colorado, University, Boulder) and T. L. HOLST (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 192-199. Previously cited in issue 07, p. 853, Accession no. A85-19739. refs
(Contract NCA2-OR-170-202)

**A86-28563#**
**A NEW AND LESS COMPLEX ALTERNATIVE TO THE HANDLEY PAGE SLAT**
A. L. WILLIAMS (Northrop Corp., Aircraft Div., Hawthorne, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 200-206. refs

A comparative evaluation is made of the aerodynamic effects and mechanical requirements of devices that have been adopted to delay leading edge stall, such as the Handley Page slat and Kruger flap. While a flexible fiberglass Kruger flap that incorporates the 'ever-opening spiral' geometry allows high lift coefficient to be achieved at high inflow angles, it is a mechanically complex device; attention is accordingly given to the design features and advantages of an ever-opening spiral principle four-bar linkage device that answers to such criteria as compactness. The simplicity thus achieved has led to time and cost reductions in design, fabrication and maintenance. The device may be retrofitted to update existing aircraft. O.C.

**A86-28566#**
**STALINS METHOD FOR TAKEOFF AND LANDING TRAJECTORY MEASUREMENTS**
C. G. KRANENBURG, A. POOL, and A. J. L. WILLEKENS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 678-684) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 220-225. Research supported by the Nederlands Instituut voor Vliegtuigoutwikkeling en Ruimtevaart. Previously cited in issue 22, p. 3187, Accession no. A84-45003.

**A86-28567#**
**COMPARISON OF DISCRETE AND CONTINUOUS GUST METHODS FOR AIRPLANE DESIGN LOADS DETERMINATION**
R. NOBACK (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 351-357) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 226-231. Previously cited in issue 22, p. 3186, Accession no. A84-44967. refs

**A86-29299#**
**IN-FLIGHT SIMULATORS**
J. BARRY, JR. (USAF, Wright-Patterson AFB, OH) and A. E. SCHELHORN (Calspan Corp., Buffalo, NY) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, March 1986, p. 10-16. refs

The Flight Dynamics Laboratory (FDL) has sponsored and managed the development and use of several generations of in-flight simulators during the last thirty years. These vehicles were designed and fabricated, and are operated by the Flight Research Department of Calspan Corporation, Buffalo, New York. These unique aircraft have been used to develop control laws and control systems, to evaluate new aircraft before first flight, to provide specialized training for test pilots, to perform essential flight research in flying and handling qualities, and to develop and validate the military specifications for handling qualities of piloted airplanes. As aircraft and control systems have become more complex and capable, systems integration issues have required more and more effort resources. Author

**A86-29823**
**CAD/CAM SUPPORTS FLIGHT TEST MODIFICATIONS**
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, March 1986, p. 22-27.

An evaluation is made of an aircraft modification/modernization program that incorporates state-of-the-art computer-integrated engineering and manufacturing techniques. The modification center's computer-aided design techniques have been employed to determine optimum placement for new aircraft instrumentation and for the addition of a conformal strap to the structural casing of an aircraft bulkhead for stress relief. Computer-aided manufacturing has been used in previously underestimated prototype construction activities, with high productivity ratings resulting from the ease with which design modifications could be inserted into the numerical control code. Attention is given to the radome nose structure modification work undertaken for the EC-18B aircraft. O.C.

**A86-29824**
**SOLAR POWERED VEHICLE MAY FLY YEAR-LONG MISSIONS**
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, March 1986, p. 54-59.

Attention is given to the performance requirements and projected design features of a solar cell-based propulsion unmanned aircraft type designated the 'high altitude powered platform' (HAPP). During daylight hours, the electrical propulsion system would receive its power directly from solar cell arrays covering the upper surfaces of the aircraft; nocturnal propulsion power is furnished by fuel cells that would have been charged by excess daylight power. HAPP aircraft, which may typically have a 300-ft wingspan, would fly at 65,000 ft for essentially unlimited periods (terminated for the sake of maintenance); their mission would be to carry earth resources sensors and transmit the data they obtain to ground stations. O.C.

**A86-29842**
**STRENGTH ANALYSIS OF FLIGHT VEHICLES [RASCHET NA PROCHNOST' LETATEL'NYKH APPARATOV]**
A. S. AVDONIN and V. I. FIGUROVSKII Moscow, Izdatel'stvo Mashinostroenie, 1985, 440 p. In Russian. refs

Applied methods of static strength analysis of flight vehicles, including aircraft, rockets, and spacecraft, are presented. In particular, attention is given to the analysis of loads acting on flight vehicles in flight and during landing; the heating of flight vehicle structures; and methods of the strength analysis of wings of various configurations, including finite element analysis in displacements and forces. The discussion also covers the strength analysis of wings and tail units, chassis, engine installations, fuselage, and other structures; minimum-weight design; and fatigue strength analysis. V.L.

**N86-20385#** National Aeronautical Lab., Bangalore (India). Structural Sciences Div.
**MODAL ANALYSIS OF A TYPICAL FIGHTER AIRCRAFT USING TRANSIENT TESTING TECHNIQUE**
R. BALASUBRAMANIAM, D. S. RAMAKRISHNA, and P. S. VIJAYAKUMAR Dec. 1985 30 p refs
(NAL-TM-ST-8517) Avail: NTIS HC A03/MF A01

The dynamic performance of individual structural components and the whole aircraft was evaluated. The dynamic properties of the aircraft and its components were analyzed. One hundred and thirty-nine locations for transient imputs are chosen using an instrumented hammar and on-line data reduction for modal properties. Results from up to six modes of the natural frequency modal mass ans stiffness and damping tests are presented. The test set-up, choice of locations for excitations, and actual test procedures are outlined. The advantages of sweep-sine, step relation random and transient test methods on aircraft structures are discussed. E.A.K.

**N86-20386*#** Florida Univ., Gainesville. Dept. of Engineering Sciences.
**OPTIMAL AIRFRAME SYNTHESIS FOR GUST LOADS Final Report**
P. HAJELA Feb. 1986 45 p refs
(Contract NAG1-579)
(NASA-CR-178047; NAS 1.26:178047) Avail: NTIS HC A03/MF A01 CSCL 01C

An optimization capability for sizing airframe structures that are subjected to a combination of deterministic and random flight loads was established. The random vibration environment introduces the need for selecting a statistical process that best describes the random loads and permits computation of the dynamic response parameters of interest. Furthermore, it requires a formulation of design constraints that would minimize the conservativeness in the design and retain computational viability. The random loads are treated as a stationary, homogeneous process with a Gaussian probability distribution. The formulation of the analysis problem, the structure of the optimization programming system and a representative numerical example are discussed. Author

**N86-21532** Royal Aircraft Establishment, Farnborough (England).
**STRUCTURAL MATERIALS IN AERONAUTICS: PROSPECTS AND PERSPECTIVES**
G. G. POPE 28 Aug. 1985 45 p refs Presented at European Pioneers Day Meeting, Paris, 25 Apr. 1985
(RAE-TR-85077; BR97329) Avail: NTIS HC A03/MF A01

Developments in materials and their prospects of application in airframes and engines are reviewed. Technical and cost considerations that govern material selection; and the merits of fiber composites, titanium alloys, steels and aluminum alloys for airframe applications are examined. The benefits offered by fiber composites must be assessed for specific applications in relation to developments in aluminum alloys, notably lithium-containing alloys and alloys produced by rapid solidification or condensation. Titanium alloys and steels are expected to fulfil an important but limited role in airframes. In the engine, titanium and nickel-base alloys respectively will satisfy most compressor and turbine requirements, although use of ceramics is expected. It is concluded that new materials are acceptable only if a clear understanding is achieved of the relationship between composition, microstructure and material behavior, the manufacturing route, and quality control of the product. Author (ESA)

**N86-21533#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
**A PROGRAMME OF RESEARCH INTO THE AERODYNAMICS, STABILITY AND CONTROL CHARACTERISTICS OF A COMBAT AIRCRAFT HAVING A FORWARD SWEPT WING Interim Report, Nov. 1984 - Oct. 1985**
M. V. COOK and F. HEYDARI Oct. 1985 16 p refs CAR-8516
ISBN-0-947767-27-4
Avail: NTIS HC A02/MF A01

The aerodynamic stability and control characteristics of the forward swept wing aircraft, and likely stability augmentation requirements were studied. It is found that: (1) the theoretical aerodynamic models match the observed aerodynamic performance; (2) the estimated stability derivatives when incorporated in a computer simulation provide response characteristics which agree with experimentally derived responses; (3) the parametric identification technique is effective; (4) theoretical predictions of longitudinal static stability margins indicate that the aircraft is more stable than observed in experiments; (5) feedback control is relatively straightforward; and (6) the experimental system permits dynamic testing on the aircraft model with a longitudinal static stability margin as small as -4%. E.A.K.

**N86-21534*#** National Aeronautics and Space Administration, Washington, D.C.
**PROCEDURE FOR UTILIZING THE LIFT AND THRUST FORCES OF ORNITHOPTERS**
C. BEZARD Nov. 1985 15 p Transl. into ENGLISH of French Patent no. 8404354 (21 Mar. 1984) p 1-15 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77682; NAS 1.15:77682) Avail: NTIS HC A02/MF A01 CSCL 01C

This procedure is distinguished by two beating wings which together describe, in space, a succession of interlaced triangles. On these wings, whose incidence varies automatically, identical forces are exerted: simultaneous lift and thrust when they make their descent, which is inclined toward the front of the craft, and lift alone when they make their ascent, which is inclined toward the rear of the craft and follows a slide horizontal movement. A mechanical device makes these movements possible. It includes: two wings with hollow profiles, connected by a framework located above a rigid frame and attached to it by bars with joints. These bars are moved with control rods which gear down the drive force. A mechanism with elastic bands or springs automatically varies the incidence of the wings. Author

**N86-21535*#** National Aeronautics and Space Administration, Washington, D.C.
**VERTICALLY OPERATING FLIGHT VEHICLE FOR DRILLING AND AGRICULTURAL USE**
W. PABST Mar. 1986 13 p Transl. into ENGLISH of West German Patent no. P3521624.7 (10 Jun. 1985) p 1-12 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77713; NAS 1.15:77713) Avail: NTIS HC A02/MF A01 CSCL 01C

The invention deals with an aircraft which ascends and descends vertically and which is used for recreational aircraft, as well as for drilling and in agriculture. The invention combines the floating effect of a parachute with the helicopter to develop a flight vehicle with multiple uses which go beyond those of contemporary flight vehicles. Both hub mechanisms and thrust power are implemented to achieve this goal. Four designs are described in detail. Author

**N86-21536#** Boeing Co., Seattle, Wash.
**OPERATION REDWING, PROJECT 5.2, IN-FLIGHT PARTICIPATION OF A B-52**
F. L. WILLIAMS 1 Apr. 1985 69 p refs Prepared in cooperation with Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio Prepared for DNA, Washington, D.C.
(AD-A995286; WT-1328-EX) Avail: NTIS HC A04/MF A01 CSCL 18C

Measured energy input and aircraft response data on an instrumented B-52 aircraft when subjected to the thermal, blast, and gust effects of a nuclear explosion were examned. The spatial location for the B-52, relative to a detonation, that would result in the desired aircraft inputs and responses was analyzed. The B-52 participated in nine shots. The reliability of the instrumentation system was between 95% and 100% throughout the test program. It is recommended that the B-52 not participate in future nuclear tests as a weapons-capability aircraft. E.A.K.

**N86-21537#** Aeronautical Research Labs., Melbourne (Australia).
**COMPARISON OF AIRBORNE DATA ACQUISITION SYSTEMS AT ARL (AERONAUTICAL RESEARCH LABORATORIES)**
G. F. FORSYTH Sep. 1985 13 p
(AD-A161664; ARL/AERO-PROP-TM-430) Avail: NTIS HC A02/MF A01 CSCL 09B

During formulation of plans to raise contracts to implement a new data acquisition arrangement to suit aircraft engines and other propulsion components, it became necessary to evaluate other systems which might be available for the same or similar tasks. Accordingly details have been collected on all the various airborne data acquisition systems which may be considered for use at ARL. Later sections of this paper compare the major capabilities of the various airborne data acquisition systems currently available at ARL and of some systems which have recently become available from industry. GRA

**N86-21539#** Naval Postgraduate School, Monterey, Calif.
**HELICOPTER PERFORMANCE COMPUTER PROGRAMS FOR HP-41 HAND-HELD COMPUTER**
D. M. LAYTON Dec. 1985 73 p
(AD-A162794) Avail: NTIS HC A04/MF A01 CSCL 01C

This document has reference tables and programs used to evaluate helicopter performance in the areas of: Autorotation; Service and Combat Ceilings; Basic Power Required Parameters; Fuel Consumption; High Speed Effects; Basic Power Considerations; Maximum Endurance Power/Velocity; Maximum Rage Power/Velocity; and Weight Estimation Relationships. These programs present the user of the HP-41 hand-held, programmable calculator with a series of self-prompting, alphanumeric programs that can be used with acceptable results to compute and evaluate helicopter performance. Most of the programs are structured so as to be more expedient when doing preliminary helicopter design where intermediate values are of less a concern than would be the case when studying detailed performance. GRA

**N86-21540#** Department of the Air Force, Washington, D.C.
**ROBOTIC REFUELING SYSTEM FOR TACTICAL AND STRATEGIC AIRCRAFT Patent Application**
E. R. SCHULTZ, inventor (to Air Force) 12 Aug. 1985 17 p
(AD-D011980; US-PATENT-APPL-SN-764820) Avail: NTIS HC A02/MF A01 CSCL 01B

A ground based aircraft refueling system uses existing air-to-air refueling technology. A fixed facility design attaches a moveable air-to-air type refueling boom and probe to an overhead track mounted on the ceiling of a TAB VEE aircraft shelter. Movement of the boom and probe is controlled from a remote control room protected from hazardous chemical and biological environments. In a second embodiment a moveable facility design mounts on the top of a tank truck a first boom attached at a right angle to an air-to-air type refueling second boom and probe. The booms and probe are remotely controlled from the truck cab which is protected from hostile chemical and biological environments. A third embodiment adds to the moveable facility design a second tank and nozzle outlet for spraying decontaminate.
Author (GRA)

**N86-21541#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Forschungsbereich Nachrichtentechnik und Erkundung.
**THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF FLOW VECTOR MEASUREMENTS WITH ANGLE-OF-ATTACK AND SIDESLIP SENSORS ON DFVLR METEOROLOGICAL RESEARCH AIRCRAFT Ph.D. Thesis - Technische Univ., Munich, West Germany**
P. MUEHLBAUER Jun. 1985 132 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-976)
(DFVLR-FB-85-50; ISSN-0171-1342) Avail: NTIS HC A07/MF A01; DFVLR, Cologne DM 42.50

Calibration of the equipment of three powered sail planes and a jet plane with angle-of-attack and sideslip sensors for measuring the local flow vector is described. The impact of angle-of-attack and sideslip and of other interfering parameters on the measured value was studied. A mathematical simulation of compressible flow at the tip of the probe is followed by experimental wind tunnel investigations, analysis, and application on in-flight measurement. Criteria for flight-test use of the sensors are outlined.
Author (ESA)

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-26504#**
**AVNER ELECTRONIC MAGNETIC COMPASS AND LOW COST NAVIGATION SYSTEM**
A. SOBEL (Elbit Computers, Ltd., Ground Systems Div., Haifa, Israel) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 22-28.

A new type of Electronic Magnetic Compass has been developed by Elbit Computers Ltd. This compass corrects the deviations in the Magnetic Compass reading, when mounted on iron body vehicles, by using a classic formula implemented by a microprocessor. This compass is so flexible that it can even correct the deviations caused by the iron body of tanks with rotatable turret. The compass is self calibrated by a computer program which relieves the crew from the complexity of the process. It is argued that this compass has the potential of becoming a low-cost solution to the navigational problems of the large mass of military and commercial land vehicles, aircraft, and ships operating on its own and in conjunction with GPS. The concept and the construction of the compass is explained, some experimental results, and the project status are given. Author

**A86-27818**
**FLIGHT TEST INSTRUMENTATION SYSTEM FTIS FOR TYPE-CERTIFICATION OF THE INDONESIAN AIRCRAFT CN 235**
H.-J. KLEWE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) and A. D. SOELAIMAN (Nurtanio Aircraft Industry, Ltd., Bandung, Indonesia) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 563-573. refs

A survey of the complete Flight Test Instrumentation System (FTIS) for certifying the Indonesian aircraft CN 235 is presented. The FTIS's necessary data acquisition and evaluation systems are described along with the subsystems necessary for flight testing, such as airborne and ground-calibration systems, video and camera installations. The subsystems of the mobile ground station, which is housed in 14 shelters including a power station and can be seen as a self-supporting system, are covered. C.D.

**A86-28066**
**COLOUR DESIGN IN AVIATION CARTOGRAPHY**
R. M. TAYLOR (RAF, Institute of Aviation Medicine, Farnborough, England) Displays (ISSN 0141-9382), vol. 6, Oct. 1985, p. 187-201. refs

The use of color in maps from the earliest times to the present day is reviewed, and that experience is applied to the problems of airborne map displays. Studies of the priorities of various kinds of map information have been carried out. A set of principles and guidelines for the best use of color in airborne map displays is given. Author

**A86-28346**
**DIGITAL AVIONICS FOR MODERN AIRCRAFT - A CASE STUDY INTO THE PROBLEMS AND PROMISE OF AIRCRAFT ELECTRONICS**
H. S. ARCHER, III (Lockheed-Georgia Co., Marietta) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 144-151.

With decreasing static stability margins and increasingly rigorous mission requirements, the role of aircraft electronics has become vital. A brief historical perspective of the evolution of avionics is given, and the harsh environmental constraints under which current avionics must operate are noted. The case for spatially redundant integrated racks composed of standardized modules is made. A state-of-the-art design approach is then presented, followed by a discussion of an advanced system that will be typical of aircraft in the 1990's. The topics discussed include: designing for thermal management, distributed processing, built-in-test requirements, and redundant systems for flight-critical applications. Author

**A86-28362**

### HIGH STABILITY PRESSURE TRANSDUCERS FOR AIR DATA SYSTEMS AND TEST SETS

D. W. BUSSE and D. F. PETERSON (Paroscientific, Inc., Redmond, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 270-274.

The design and the operational principles of a digital quartz pressure transducer are presented, together with its pressure/frequency relationship equation and an algorithm for temperature compensation. The characteristics of these transducers include a high operating temperature range (from -54 C to +107 C); high shock and vibration resistance of the isolation housing, which can withstand MIL-STD environments; and long term calibration stability, with the drift rates less than 0.089 millibars/year. The low sensitivity to harsh environments and to power supply fluctuation, and the high level digital output make the quartz pressure transducers ideally suited for many flight applications. I.S.

**A86-28363**

### A NOVEL PRIMARY AIR DATA QUALITY PRESSURE TRANSDUCER

P. B. DUPUIS (Honeywell, Inc.; Commercial Aviation Div., Minneapolis, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 275-283. refs

A state-of-the-art pressure transducer is described that senses both pitot and static pressures within a single solid-state sensor. This small, relatively simple, and easily interfaced transducer provides exceptional accuracy and long-term stability over a broad environmental range. The transducer's small size will enable Honeywell to integrate an ARINC 706 equivalent air data computer within an ARINC 704 inertial reference system. Remotely located pressure transducers having ARINC 429 outputs of linearized total pressure (Pt), static pressure (Ps), and impact pressure (Qc) are also made possible by this transducer. Incorporation of this transducer into flight hardware began with the latest HG480 and HG280D80 air data computers, which are standard equipment in Boeing 737-300, Douglas MD-80 and KC-10 series aircraft. This transducer is also being used in an Engine Pressure Ratio (EPR) system for the Fokker F28 MK100 and Gulfstream G-IV aircraft. Author

**A86-28364**

### WIND TUNNEL CALIBRATION OF A FLOW DIRECTION SENSOR AND A PITOT-STATIC TUBE TO HIGH ANGLES OF ATTACK AND SIDESLIP

F. W. HAGEN and R. V. DELEO (Rosemount, Inc., Eden Prairie, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 284-290.

Modern high performance military aircraft require accurate air data measurements while operating in maneuvering flight at very high angles of attack and angles of sideslip. Inflight calibration of the air data systems is difficult under these flight conditions. Flight test data obtained on an F-14 are believed to be inaccurate and not representative of actual performance. Therefore, the accuracy of air data measurements at high local flow angles has been evaluated in the Rosemount Transonic Wind Tunnel for two types of air data sensors. The sensors are: (1) a hemispherical flow-angularity sensor that measures both angle of attack and angle of sideslip, and (2) an L-shaped fuselage-mounted pitot-static tube. Author

**A86-28367**

### A MODULAR STRESS MANAGEMENT SYSTEM (MSMS) WITH WORLDWIDE APPLICATIONS

C. J. RADFORD (GEC Avionics, Ltd., Rochester, England) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 317-325.

The paper describes a universal Modular Stores Management System (MSMS) design concept, which features low development costs and timescales, commonality between aircraft types, and VLSI technology, providing high reliability and a common product support and maintenance philosophy. The MSMS was successfully applied to 19 types of aircraft, including E-111, P-3, A-7, and AV-8B, and was shown to be capable of interfacing with at least 11 different weapon systems, including Sea Eagle, JP 233, HARM, and ALARM. In addition, the MSMS can control an extensive range of conventional bombs and mines, nonweapons (such as carriers, launchers, and pods), and particle weapons. The MSMS is MIL-STD-1760A/STANAG 3837AA compatible. I.S.

**A86-28371#**

### ADAPTIVE FIELD OF VIEW EXPANSION VIA MULTIPLE MODEL FILTERING FOR TRACKING DYNAMIC TARGET IMAGES

P. S. MAYBECK and R. I. SUIZU (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 364-373. refs

Multiple model adaptive estimation is investigated as a means of changing the field-of-view as well as the bandwidth of an infrared image tracker against a wide dynamic range of targets. The multiple models are created by tuning the filters for best performance at differing conditions of exhibited target behavior and differing the physical size of their respective fields of view, and probabilistically weighted averaging provides the adaptation mechanism. Each filter involves online identification of the target shape function, so that this algorithm can be used against ill-defined and/or multiple-hot-spot targets. When each individual filter has the form of an enhanced correlator/linear Kalman filter, computational loading is very low, whereas an extended Kalman filter, processing the raw infrared data directly and assuming a nonlinear constant turn-rate target dynamics model provides superior tracking capability, especially for harsh maneuvers. Author

**A86-28390**

### IMPLEMENTATION OF TF/TA IN THE DIGITAL TERRAIN MANAGEMENT AND DISPLAY SYSTEM

P. WHITEMAN and G. L. MIZE (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 531-537. Research supported by General Dynamics Corp.

The configuration of the digital terrain management and display system (DTMDS) is described. The functions of the database, output video, symbol generation, and autonomous navigation processings are analyzed. The algorithms for terrain avoidance (TA) and terrain following (TF) are studied. The development and maintenance of the local terrain elevation database for TA/TF are investigated; the access method for TA/TF to the DTMDS map is examined. Algorithm simulations and processor landing analyses of the TA/TF system are discussed. I.F.

**A86-28463#**

### EMBEDDED TRAINING AVIONICS INTEGRATION

I. V. GOLOVCSENKO and A. J. BALAZS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1120-1124. refs

Advanced concepts of embedded operational training are examined which future airborne system technology could support. Embedded training involves the shared use of operational and training equipment in an aircraft; it consists of embedding into aircraft systems (particularly the avionics) the capability to conduct airborne training operations including flight against on-board generated 'threats'. The cockpit of the 1990s will very likely be highly dependent of real-time computer generated displays, including heads-up, tactical situation, multisensor, helmet mounted and system status monitor displays. A variety of information, including terrain imagery, moving maps, threats, symbology, and pathways in the sky, will be integrated and presented. The Pave Pillar program is discussed as an example of an approach to a large highly integrated avionics system. Author

**A86-28464**

### ONBOARD SIMULATION - A DEMONSTRATED TECHNOLOGY BREAKTHROUGH FOR COST EFFECTIVE TESTING AND TRAINING

B. J. BRADY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), R. G. HUGHES (USAF, Human Resources Laboratory, Williams AFB, AZ), and J. H. CARLSON (McDonnell Aircraft Co., St. Louis, MO) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1126-1131. refs

The aircrew training aspects of the Onboard Simulation system are examined. The baseline Onboard Simulation system was developed as part of the Air Force Integrated Flight/Fire Control (IFFC) program, as described by Lambert (1982). Training currently consists of a mix of academics, training devices including operational simulators, and flight training on local ranges and instrumented test ranges which provide for electronic warfare and composite force training. The use of Onboard Simulation, augmenting conventional simulation and range capabilities, will significantly increase pilot effectiveness and decrease future test and evaluation and training costs. D.H.

**A86-28465#**

### DESIGN CONSIDERATIONS FOR ON-BOARD SIMULATION

D. R. BREGLIA (U.S. Navy, Naval Training Equipment Center, Orlando, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1132-1137. refs

Design implications of embedded training for the F/A-18 aircraft (a multi-role, high performance, single-seat tactical aircraft) are discussed. The primary mission areas are: anti-air warfare; anti-surface warfare; strike arfare; amphibious warfare; mine warfare; mobility; and command, control, and communication. The current F/A-18 training syllabus is reviewed and those training events which can be supplemented and enhanced through the use of on-board simulation are identified. Five design approaches for embedded training systems are related to the training events. D.H.

**A86-28478**

### ULTRASONIC LIQUID QUANTITY MEASUREMENT

E. T. RUTLEDGE (Lockheed-Geogia Co., Marietta, GA) IN: NEACON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1236-1242.

Mechanical and electrical techniques are examined for measuring liquid quantitiess, by using ultrasonic generators as a signal source. Existing techniques for measuring liquid quantities in aircraft use transducers which ae not only inaccurate and unreliable but which are frequently difficult to maintain. The techniques proposed for using ultrasonic transducers improve on all of the areas of deficiency and obviate the need for aircraft power in the fuel cells or other liquid containers. As a specific application of the technology, measurement of the engine oil quantity for the Lockheed-Georgia C-130 aircraft is considered. D.H.

**A86-28505**

### ELECTRONIC DISPLAY LUMINANCE AND GREY SCALE CONTROL

K. T. BURNETTE (Burnette Engineering, Fairborn, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1500-1510. refs
(Contract F33615-81-C-3620; F33615-84-C-3627)

The role that luminance plays in making information depicted on military aircraft video displays both perceptible and interpretable by a pilot is explored. Particular design criteria issues are investigated that involve electronic display luminance and grey scale control: display luminance uniformity, sensor/video system signal transfer characteristics, display picture grey shade content, and the effects of cockpit illumination and glare source viewing conditions. D.H.

**A86-28506**

### APPLICATION OF MAGNETO-OPTIC MODULATORS TO ADVANCED AVIONIC DISPLAYS

A. J. MOFFAT, A. QUAGLIA, and R. C. BAJCAR (Litton Systems Canada, Ltd., Rexdale, Canada) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1511-1518. refs

The magnetooptic light modulator (based on the Faraday effect) is examined as a means of significantly improving avionics displays for future aircraft. The light modulator has application to high brightness raster-scan projector systems suitable for use in head-up displays, head-down displays, and helmet mounted displays. The basic principles of the device and its characteristics are explained. D.H.

**A86-28507*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

### A CONSTANT ALTITUDE FLIGHT SURVEY METHOD FOR MAPPING ATMOSPHERIC AMBIENT PRESSURES AND SYSTEMATIC RADAR ERRORS

T. J. LARSON and L. J. EHERNBERGER (NASA, Flight Research Center, Edwards, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1519-1526. Previously announced in STAR as N85-29951. refs

The flight test technique described uses controlled survey runs to determine horizontal atmospheric pressure variations and systematic altitude errors that result from space positioning measurements. The survey data can be used not only for improved air data calibrations, but also for studies of atmospheric structure and space positioning accuracy performance. The examples presented cover a wide range of radar tracking conditions for both subsonic and supersonic flight to an altitude of 42,000 ft. Author

**A86-28511**
**REAL-TIME CIRCLE GENERATION FOR RASTER DISPLAYS**
R. J. CARUSO (BDM Corp., Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1549-1555. refs

A new method of drawing circles in real time for aircraft displays is presented. If a fixed-size circle needs to be drawn over and over in a real-time display, most circle algorithms spend a significant amount of time recomputing a fixed set of relative points. The new method employs a circle primitive with run-time efficiency; it computes the points needed for an octant of the circle just once, then stores them in reduced form, and uses them as a template for the rest of the circle and for subsequent drawings of the same circle. The problem is analyzed and the algorithm is given. D.H.

**A86-28512**
**PILOT/VEHICLE INTERFACE DESIGN SYSTEM (PIVIDS)**
R. D. MOORE and C. A. MOORE (Verac, Inc., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1556-1563.

A concept for a rapid prototyping simulator for the cockpit display problem has been developed. Called the Pilot Vehicle Interface Design System, or PIVIDS, the system is a response to the problem of evaluating the pilot/vehicle interface with regard to complex, new multifunction displays. The F-16C/D cockpit, which has ten computers (communicating with each other over three multiplex buses) and a variety of display units, is considered as an example where PIVIDS can greatly aid the designer. The system is suited to a broad range of other applications. D.H.

**A86-28515**
**THE CREW STATION INFORMATION MANAGER - AN AVIONICS EXPERT SYSTEM**
L. D. POHLMANN (Boeing Military Airplane Co., Wichita, KS), P. S. MARKS, and M. R. FEHLING (Advanced Information and Decision Systems, Mountain View, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1576-1582. refs
(Contract F33615-83-C-1083)

Progress to date is reported on the development of CSIM, the Crew Station Information Manager, which is a prototype avionics expert system being designed and developed under contract to the Air Force Avionics Laboratory. The function of CSIM is to manage the interface between the pilot and the avionics suite of a future tactical aircraft. A review is given of program motivation and objectives, and a set of avionics expert system candidates is identified. Preliminary development and early simulation are discussed, and near-term plans are outlined in connection with a contract extension sponsored by DARPA. D.H.

**A86-28516**
**EXPERT SYSTEM PILOT AID**
J. R. JURGENSEN and R. E. FELDMANN (Systran Corp., Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1583-1590.

A status report is given for the Expert System Pilot Aid (ESPA) small-business contract with Air Force Avionics Laboratory to study the application of expert system programming techniques to the advanced fighter cockpit. Topics covered include: heuristics vs deterministics; expert system language selection (a modified OPS-5 language is chosen); and mission analysis (emergency scenarios: landing gear failures, engine failure at altitude, system failure during takeoff). A simulation evaluation of ESPA is to be made using the Avionic System Analysis and Integration Laboratory (AVSAIL) facility at Wright Patterson Air Force Base. D.H.

**A86-28842**
**LANTIRN FLIGHT TEST - OPENING THE NIGHT WINDOW**
G. W. MATTHES (USAF, Flight Test Center, Edwards AFB, CA) Cockpit (ISSN 0742-1508), Oct.-Dec. 1985, p. 5-20.

The development and testing aspects of the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN) are discussed. The features and the capabilities of the three LANTIRN subsystems a Wide Angle Raster HUD, a navigation pod, and a targeting pod, are presented together with some testing results. Special attention is given to the testing of the LANTIRN's Navigation Pod and its components, the Environmental Control Unit, the Terrain Following Radar (TFR), and the infrared Fixed Imaging Navigation Sensor (FINS). The system integration testing of the Navigation Pod has shown that the combined effect of the easy to fly TFR guidance and the anticipation cues given by the FINS video make the operations of the night low level flying and weapon delivery, and the exercise of tactically sound egress techniques comparable with the same operations performed in the day low level flying. I.S.

**N86-20387** Department of the Air Force, Washington, D.C.
**ASYMMETRIC THRUST WARNING SYSTEM FOR DUAL ENGINE AIRCRAFT Patent**
W. W. STOCKTON, inventor (to Air Force) 8 Oct. 1985 4 p
Supersedes AD-D010978
(AD-D011960; US-PATENT-4,546,353;
US-PATENT-APPL-SN-577412; US-PATENT-CLASS-340-966)
Avail: US Patent and Trademark Office CSCL 01D

An asymmetric thrust warning system for an aircraft having two gas turbine engines. The compressor discharge pressures of the two engines are compared to determine the engine providing the lower thrust and to provide a signal indicative of the actual difference in thrust. If the difference in thrust exceeds a prescribed value related to aircraft altitude, a low thrust warning lamp is illuminated. In addition, the positions of the two augmenter metering valves are compared. If their positions significantly differ, the warning light associated with the valve having the minimum opening will be illuminated. A stall warning circuit may also be included as a part of the system. GRA

**N86-20388#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**AVIONICS STANDARDIZATION: PERCEPTIONS AND RECOMMENDATIONS M.S. Thesis**
J. A. FURRU Sep. 1985 139 p
(AD-A161709; AFIT/GSM/LSY/85S-11) Avail: NTIS HC A07/MF A01 CSCL 15E

This research effort reflects the perceptions and attitudes about avionics standardization by some members of the acquisition community. All of the interviewees were knowledgeable on the subject of and many had extensive experience with, avionics standardization. They either were currently working or had previously worked with avionics standardization. The analysis reflects some of the attitudes about the policies and procedures of avionics standardization and the role of the Deputy for Avionics Control in the process of standardization. The analysis also includes recommended changes to the current process of standardizing avionics equipment. The result of the research effort shows that the acquisition community has not accepted avionics standardization for a number of reasons. GRA

**N86-20401#** Marconi Avionics Ltd., Rochester (England). Flight Controls Div.
**DIGITAL FLY-BY-WIRE EXPERIENCE**
A. D. HILLS *In* AGARD Fault Tolerant Hardware/Software Architecture 8 p Sep. 1985 refs
Avail: NTIS HC A07/MF A01

A description of two recent GEC Avionics (GAv) systems is included: (1) A310 Slats and Flaps Control System; and (2) Jaguar FBW Demonstrator Flight Control System. Particular reference is made to the architecture of the computers and embedded software. Data is included on the two different system design requirements, especially those relating to integrity and availability. Emphasis is placed on the reasons for selecting dissimilarity, as an implementation philosophy, for the A310 system, as against the multiple similar Jaguar demonstrator architecture. The paper then provides a brief description of the design and development program for the two computer units with emphasis on lessons learned, specially in the software areas. The aspects of the system and computer design involved with maintainability and reliability are detailed and current in-service experience discussed where applicable. Conclusions are drawn particularly on dissimilarity, highlighting lessons learned from these successful FBW programs. A potential method of providing software fault tolerance within a dissimilar implementation is discussed and preliminary results of a GEC research program in this area provided. Author

**N86-20405#** Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse (France).
**DEPENDABLE AVIONIC DATA TRANSMISSION**
D. R. POWELL and J. C. VALADIER *In* AGARD Fault Tolerant Hardware/Software Architecture 19 p Sep. 1985 refs
Sponsored in part by Direction des Recherches, Etudes et Techniques. Prepared in cooperation with Crouzet Aerospace and Systems, Valence, France, and Electronique Serge Dassault, St. Cloud, France
Avail: NTIS HC A07/MF A01

This paper outlines the major constraints imposed on the design of dependable local area networks for avionic systems and underlines the essential differences in requirements that exist with respect to those of ground-based (civil) LANs. The different choices available to the system designer are then discussed: technology (electrical or optical), architecture (bus or loop), general philosophy (centralized or decentralized), medium access control (competition or consultation). The paper then goes on to summarize two different and independent avionic LAN research projects; one which focusses on fault and damage-tolerance and the other on high-speed. Author

**N86-20407#** Massachusetts Inst. of Tech., Cambridge. Lab. for Computer Science.
**DESIGN ISSUES IN DATA SYNCHRONOUS SYSTEMS**
G. M. PAPADOPOULOS *In* AGARD Fault Tolerant Hardware/Software Architecture 12 p Sep. 1985 refs
Avail: NTIS HC A07/MF A01

Fault tolerant data synchronous systems are ones where the outputs of all correctly operating redundant channels are guaranteed to bit-for-bit agree, independent of whether the channels are clock, instruction or frame synchronous. Data synchronous systems offer a form of fault tolerant processing capable of correctly supporting a very general class of programs. In fact, the redundancy becomes relatively transparent to the programmer of applications for data synchronous systems, making them ideally suited for complex, algorithmically intensive programs that would be otherwise impossible to support. The various aspects of the design of correct data synchronous systems are examined in detail. These include: Source consistency, the requirement that all correctly operating channels receive precisely the same inputs, Event synchronization, the problem of keeping the time skew between channels within predetermined bounds, as well system initialization. The unsolved problem of latent faults is also presented along with the need for self-test heuristics. Sequential fault tolerant and parallel fault tolerant approaches are contrasted for systems requiring protection from multiple faults. Both hardware and software solutions to these problems are given, emphasizing system performance and economy. The paper concludes with the application of these techniques to the design of triplex fail-operational and quadruplex and dual-dual fail-operational-fail-operational systems. Author

**N86-20408#** Northrop Corp., Hawthorne, Calif. Aircraft Div.
**DIGITAL FAULT-TOLERANT FLIGHT ACTUATION SYSTEMS**
H. H. BELMONT *In* AGARD Fault Tolerant Hardware/Software Architecture 19 p Sep. 1985
(Contract F33615-80-C-3623)
(AFWAL-83-3041) Avail: NTIS HC A07/MF A01

A study was made of the equipments making up a typical flight control actuation system (servo electronics, servo valves, actuators and transducers) to determine where digital technology could replace analog technology for the purpose of providing a more fault-tolerant flight control actuation system. The investigation involved an analysis of where digital-to-analog conversion should take place between the light control computer and the analog control surface, and led to an evaluation of several architectural design issues. Among these were how to functionally partition the system, where to locate the servo electronics, the adequacy of military standard serial bus systems for control (versus data) applications, and the feasibility of providing electronics which could survive severe environments. Several actuation system configurations were evaluated. This led to recommending, as the best development prospect, a locally integrated actuation system consisting of servo electronics, servo valves, actuators, and transducers, interfacing with a digital flight control computer over a serial bus. Author

**N86-20409#** Honeywell Systems and Research Center, Minneapolis, Minn.
**DESIGN VALIDATION OF FLY-BY-WIRE FLIGHT CONTROL SYSTEMS**
G. L. HARTMANN, J. E. WALL, JR., and E. R. RANG *In* AGARD Fault Tolerant Hardware/Software Architecture 17 p Sep. 1985 refs
Avail: NTIS HC A07/MF A01

This paper addresses the problem of design validation of fault tolerant architectures. Finite-state machines are used to formally specify flight control functions. Their application is not new to engineering practice in flight control. However, it is believed that their systematic and formal use to form the structure of the system specification will be an aid in the design phase and in the validation phase. Examples are used to illustrate their application to flight control specifications. The second portion of this paper is concerned with the problem of testing highly reliable systems. Models based on fault-trees in the early definition phase of estimating reliability are used to design tests to be performed at the iron bird state (hardware in-the-loop). Confidence in the overall system reliability is derived from a combination of component life-tests and a careful evaluation of the faults that the system is designed to accommodate without loss of control. Author

**N86-21542#** Radio Technical Commission for Aeronautics, Washington, D. C.
**MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE DISTANCE MEASURING EQUIPMENT (DME) OPERATION WITHIN THE RADIO FREQUENCY RANGE OF 960-1215 MEGAHERTZ**
20 Sep. 1985 195 p refs
(RTCA/DO-189; SC-149) Avail: NTIS HC A09/MF A01

Minimal operational performance standards for airborne distance measuring equipment (DME) operating within the radio frequency range of 960 to 1215 MHz are contained. Information needed to understand the rationale for equipment characteristics and requirements is stated along with the minimum performance standards for the equipment. These standards define required performance under standard operating conditions and stressed physical environmental conditions. The operational performance characteristics are described for equipment installations and conditions and tests that will assure the user that the equipment will perform safely and reliably in the expected operational environment are defined. A configuration of airborne equipment encompassing an antenna system, transmission lines, DME interrogator, interrogator control unit and interfaces with aircraft displays/systems are considered. B.G.

# 07

# AIRCRAFT PROPULSION AND POWER

**Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.**

**A86-26370**

### WILL 1990S AIRCRAFT BE POWERED BY PROPFAN OR ADVANCED TURBOFAN?

D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, Feb. 1986, p. 8-12.

The evolution of the engine for a next generation aircraft is discussed, with a look at the Rolls Royce designs for the two principal possibilities, the propfan and the advanced turbofan. Fuel efficiency is the driving factor for the designs, with the propfan offering a 35 percent savings, and the 4th generation turbofan presenting the possibility of a 25 percent savings as compared to modern aircraft. The pusher propfan design uses the swept propeller, contra rotating propellers, and a geared propeller drive to balance propulsive efficiency and cruise speed against noise considerations. Additional 'building block' modifications, including a new exhaust port which exits after the blade, provide additional power and reduce the length down to 17 feet. In the turbofan, placing the fan behind the core engine to remove the low pressure shaft, and the use of a contra rotating fan driven by a contra rotating turbine, allows for a smaller diameter core, a low hub/tip ratio, a high rpm core, and a corresponding reduction in specific fuel consumption. It is concluded that choice of engine designs will be dictated by the future marketplace. R.R.

**A86-26371**

### PROPFAN ENGINE DESIGNS EXAMINED

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Feb. 1986, p. 17-22.

Considerations in the design of the fuel efficient medium-sized aircraft propfan engine, and various on-going developmental efforts are reviewed. Developed because of the propeller's historical 80 percent propulsive efficiency, the propfan utilizes more blades of shorter diameter that are thinner in section and larger in chord than conventional propellers. Limited tip speeds and rear mounting design minimize cabin noise. A rear-mounted counter-rotating propeller arrangement converts swirl energy into usable thrust and is 10 percent more efficient than a single-rotating configuration. The GE unducted fan (UDF) illustrates the less complex, shorter engine that results from the direct-drive approach. Gearing allows optimization of the turbine and propeller rotation rates (increasing their efficiency), and the flexibility of configuration for front and rear mounting. In the UDF, blade speed control and pitch change will be digitally controlled to optimize propulsion efficiency in all flight regimes. The ducted propfan, though two-thirds as efficient as an equivalent propfan, is projected to be more efficient than even an advanced turbofan and has application to larger, long-range airline aircraft. R.R.

**A86-26601#**

### NONLINEAR ANALYSIS OF PRESSURE OSCILLATIONS IN RAMJET ENGINES

V. YANG (Pennsylvania State University, University Park) and F. E. C. CULICK (California Institute of Technology, Pasadena) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. Research supported by Pennsylvania State University. refs
(Contract N00014-84-K-0434)
(AIAA PAPER 86-0001)

Pressure oscillations in ramjet engines have been studied using an approximate method which treats the flow fields in the inlet and the combustor separately. The acoustic fields in the combustor are expressed as syntheses of coupled nonlinear oscillators coresponding to the acoustic modes of the chamber. The influences of the inlet flow appear in the admittance function at the inlet/combustor interface, providing the necessary boundary conditions for calculation of the combustor flow. A general framework dealing with nonlinear multi-degree-of-freedom systems has also been constructed to study the time evolution of each mode. The results obtained serve as a basis for investigating the existence and stabilities of limit cycles for acoustic modes. As a specific example, the analysis is applied to a problem of nonlinear transverse oscillations in cylindrical combustors. Author

**A86-26902*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### FORCED RESPONSE ANALYSIS OF AN AERODYNAMICALLY DETUNED SUPERSONIC TURBOMACHINE ROTOR

D. HOYNIAK (NASA, Lewis Research Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) IN: Vibrations of blades and bladed disk assemblies; Proceedings of the Tenth Biennial Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 10-13, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 1-13. NASA-supported research. refs

The effect of aerodynamic detuning on the supersonic flow induced forced response behavior of a turbomachine blade row is analyzed using an aeroelastic model. The rotor is modeled as a flat plate airfoil cascade representing an unwrapped rotor annulus; the aerodynamic detuning is achieved by alternating the circumferential spacing of adjacent rotor blades. The total unsteady aerodynamic loading on the blading, due to the convection of the transverse gust past the airfoil cascade as well as that resulting from the motion of the cascade, is developed in terms of influence coefficients. The model developed here is then used to analyze the effect of aerodynamic detuning on the flow induced forced response behavior of a twelve-bladed rotor with Verdon's Cascade B flow geometry. V.L.

**A86-26905*#** Carnegie-Mellon Univ., Pittsburgh, Pa.

### THE EFFECT OF LIMITING AERODYNAMIC AND STRUCTURAL COUPLING IN MODELS OF MISTUNED BLADED DISK VIBRATION

P. BASU and J. H. GRIFFIN (Carnegie-Mellon University, Pittsburgh, PA) IN: Vibrations of blades and bladed disk assemblies; Proceedings of the Tenth Biennial Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 10-13, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 31-40. refs
(Contract NAG3-367)

A model has been developed for studying the effect of mistuning on bladed disk vibration which has the unique feature that the extent of aerodynamic and structural interaction which it simulates can be readily varied from full coupling of all blades on the disk to coupling of each blade with only its nearest neighbors. Simulations utilizing the resulting algorithm show that limited coupling models may be used to predict the statistical distribution of blade amplitudes that characterizes the mistuning effect, which in turn determines stage durability. This approach is used to study the effect of changing various system parameters on amplitude scatter. Gas density, the number of blades on the disk, disk stiffness, and the engine order of the excitation are considered. The results are used to draw some conclusions about how to improve laboratory tests and component design. Author

**A86-27271**

### ADVANCED STRUCTURAL COMPONENTS BY SPF/DB PROCESSING

E. D. WEISERT (Ontario Technologies Corp., Menlo Park, CA) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1221-1228.

An account is given of the development status of superplastically formed and diffusion-bonded (SPF/DB) Ti alloy structures, with attention to the design criteria and propective performance improvements contemplated in the application of SPF/DB to the production of aircraft gas turbine engine compressor and fan blades. The alloys in question are Ti-6Al-4V, Ti-6Al-2Sn-4Zr-2Mo, Ti Code 12, and the developmental 'alpha-2' (titanium aluminide). The manufacturing process for a hollow fan blade is highlighted. Superior engine thrust/weight ratios are the primary goal of these development efforts. O.C.

**A86-27543**

**A LOSS OF DYNAMIC STABILITY OF THE TORSIONAL VIBRATIONS OF BLADES DUE TO CASCADE FLUTTER [POTERIA DINAMICHESKOI USTOICHIVOSTI KRUTIL'NYKH KOLEBANII LOPATOK, OBUSLOVLENNAIA RESHETOCHNYM FLATTEROM]**

A. D. LEN, A. A. KAMINER, A. L. STELMAKH, and V. A. BALALAEV (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), Jan. 1986, p. 73-77. In Russian.

Results of a systematic study of the loss of dynamic stability of the torsional vibrations of a plane compressor cascade due to cascade flutter are reported. In the experiments, each cascade consisted of three mechanically uncoupled blades with independent electromagnetic excitation. Based on the results obtained, the Strouhal numbers are determined for various angles of attack and for various relative blade pitch and stagger values. V.L.

**A86-28317**

**A UNIFIED METHOD FOR EVALUATING THE STRENGTH AND RELIABILITY OF THE BLADES OF THE AXIAL-FLOW COMPRESSORS AND GAS TURBINES OF AIRCRAFT ENGINES [UNIFITSIROVANNYI METOD OTSENKI PROCHNOSTI I NADEZHNOSTI LOPATOK OSEVYKH KOMPRESSOROV I GAZOVYKH TURBIN AVIATSIONNYKH DVIGATELEI]**

V. V. KULESHOV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 203-223. In Russian.

A unified mathematical model is proposed which relates the initial parameters of an aircraft engine to the geometrical parameters of a stage and strength and reliability parameters of the compressor and turbine blades of gas-turbine engines. Generalized expressions are obtained which relate the gas dynamic parameters and the strength characteristics of a blade. These expressions provide a convenient way to select blade parameters with allowance for specified engine parameters, design factors, and strength characteristics of the materials used. V.L.

**A86-28508**

**AIRCRAFT ELECTRICAL POWER SYSTEMS**

E. D. BEAUCHAMP (AiResearch Manufacturing Co., Torrance, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1527-1535. refs

The potential is examined for powering future aircraft environmental control systems (ECSs) by means of electric drives rather than by main-engine bleed air (which may not be as available in the next generation of engines). Several aspects of electric systems of permanent magnet, brushless induction machines and solid-state power electronics - to provide primary generation or secondary control of electric drives on aircraft - are discussed. For power distribution, conventional 120/208-V, 3-phase, 400-Hz, 270-Vdc, variable frequency/constant voltage, and variable frequency/variable voltage systems are the primary candidates. Specific examples on 270-Vdc power generation, variable speed drives for an ECS compressor and fan motors, and a variable speed drive for an engine fuel pump system are included. D.H.

**N86-20389*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**METHOD FOR IMPROVING THE FUEL EFFICIENCY OF A GAS TURBINE ENGINE Patent**

G. A. COFFINBERRY, inventor (to NASA) (General Electric Co., Cincinnati, Ohio) 5 Nov. 1985 8 p 30 Aug. 1982
(NASA-CASE-LEW-13142-2; US-PATENT-4,550,561; US-PATENT-APPL-SN-413101; US-PATENT-CLASS-60-39.02; US-CLASS-60-39.07; US-PATENT-CLASS-60-736) Avail: US Patent and Trademark Office CSCL 21E

An energy recovery system is provided for an aircraft gas turbine engine of the type in which some of the pneumatic energy developed by the engine is made available to support systems such as an environmental control system. In one such energy recovery system, some of the pneumatic energy made available to but not utilized by the support system is utilized to heat the engine fuel immediately prior to the consumption of the fuel by the engine. Some of the recovered energy may also be utilized to heat the fuel in the fuel tanks. Provision is made for multiengine applications wherein energy recovered from one engine may be utilized by another one of the engines or systems associated therewith.

Official Gazette of the U.S. Patent and Trademark Office

**N86-21543*#** National Aeronautics and Space Administration, Washington, D.C.

**HIGH FREQUENCY-HEATED AIR TURBOJET**

J. H. D. MIRON Feb. 1986 12 p Transl. into ENGLISH of Spanish Patent no. 293,727 (21 Nov. 1983) p 1-10 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77710; NAS 1.15:77710) Avail: NTIS HC A02/MF A01 CSCL 21E

A description is given of a method to heat air coming from a turbojet compressor to a temperature necessary to produce required expansion without requiring fuel. This is done by high frequency heating, which heats the walls corresponding to the combustion chamber in existing jets, by mounting high frequency coils in them. The current transformer and high frequency generator to be used are discussed. Author

**N86-21547#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

**JET ENGINE OPERATING AND SUPPORT COST ESTIMATING RELATIONSHIP DEVELOPMENT M.S. Thesis**

B. H. COX Sep. 1985 106 p
(AD-A161683; AFIT/GSM/LSY/85S-8) Avail: NTIS HC A06/MF A01 CSCL 14A

This investigation derived a jet engine Cost Estimating Relationship (CER) model from multivariate linear regression techniques. Prior to the model's development, all known jet engine cost data bases were examined for applicability to the thesis effort. After identifying constraints and limitations in the data, stepwise regression equations for analysis. The best equation was identified base on pre-established logic and statistical criteria. The equation selected had the following performance, physical, and usage variables: Turbine Inlet Temperature, Specific Fuel Consumption, Weight, and Annual Engine Flying Hours. Results of the model development can be used in comparative cost analyses of present and proposed weapon systems; in cost trade-off studies to determine impact of design alternatives for new engineers; in reports to Congress on the costs of operating engines; and in estimating budget requirements. GRA

**N86-21548#** Department of the Air Force, Washington, D.C.

**DUAL MATERIAL EXHAUST NOZZLE FLAP Patent Application**

D. O. NASH, inventor (to Air Force) 1 Oct. 1985 19 p
(AD-D011998; US-PATENT-APPL-SN-782332) Avail: NTIS HC A02/MF A01 CSCL 21E

This patent application discloses an exhaust nozzle flap capable of resisting high exhaust temperatures of turbojet engines. The flap is composed of a two-part structure of high strength metal, in a support member, combined with a heat resistant base member made from a ceramic or carbon-carbon material. The different materials in the base and support members, having substantially different rates of thermal expansion, are not bolted or riveted together, but attached in a unique manner to allow relative movement therebetween. GRA

# 08

# AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-26586**

**LOW-SPEED STABILITY CHARACTERISTICS OF A HELICOPTER WITH A SLING LOAD**

B. L. NAGABHUSHAN (Goodyear Aerospace Corp., Akron, OH) Vertica (ISSN 0360-5450), vol. 9, no. 4, 1985, p. 345-361. refs

The low-speed stability characteristics of a conventional helicopter with an external sling load on a single-point suspension are investigated using an 18th order dynamic model of the two-body system. Nonlinear equations of motion are derived which describe the six degrees of freedom rigid body motion of the helicopter, including its rotor dynamics, coupled with the longitudinal and lateral dynamics of the sling load. Significant differences, including instability and cross-coupling in the associated pendulous motion of the sling load and the inherent oscillatory motions of the helicopter, are found between operation with a short and long sling cable. Operation with a long sling cable damps out the sling-load lateral oscillation and the helicopter longitudinal phugoid, but the associated sling-load pitch oscillation and helicopter Dutch roll mode become unstable. Suspending the sling load from a point ahead of the center of gravity stabilizes the helicopter lateral oscillation, while suspending it from a point aft of the c.g. causes instability in that mode. C.D.

**A86-26629*#** Texas A&M Univ., College Station.

**AN EXPERIMENTAL STUDY OF THE LIFT, DRAG AND STATIC LONGITUDINAL STABILITY FOR A THREE LIFTING SURFACE CONFIGURATION**

C. OSTOWARI and D. NAIK (Texas A&M University, College Station) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs

(Contract NAG1-344)

(AIAA PAPER 86-0398)

The experimental procedure and aerodynamic force and moment measurements for wind tunnel testing of the three lifting surface configuration (TLC) are described. The influence of nonelliptical lift distributions on lift, drag, and static longitudinal stability are examined; graphs of the lift coefficient versus angle of attack, the pitching moment coefficient, drag coefficient, and lift to drag ratio versus lift coefficient are provided. The TLC data are compared with the conventional tail-aft configuration and the canard-wing configuration; it is concluded that the TLC has better lift and high-lift drag characteristics, lift to drag ratio, and zero-lift moments than the other two configurations. The effects of variations in forward and tail wind incidence angles, gap, stagger, and forward wind span on the drag, lift, longitudinal stability, and zero-lift moments of the configuration are studied. I.F.

**A86-26642#**

**REALTIME PILOTED SIMULATION INVESTIGATION OF HELICOPTER FLYING QUALITIES DURING APPROACH AND LANDING ON NONAVIATION SHIPS**

W. F. JEWELL, W. F. CLEMENT (Systems Technology, Inc., Mountain View, CA), and J. B. JOHNS (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs

(Contract N62269-82-C-0728)

(AIAA PAPER 86-0490)

The Naval Air Development Center (NADC) is revising the Helicopter Flying and Ground Handling Qualities Specification, MIL-H-8501A. As a part of this effort, an investigation is conducted of aspects of helicopter flight dynamics which are unique to Navy operational requirements. Clement and Jewell (1985) have discussed a piloted simulation study of helicopter shipboard landing which had been conducted in connection with this investigation. This paper is essentially a condensation of this discussion. Attention is given to a helicopter mathematical model, the Vertical Motion Simulator (VMS), the environmental conditions, and the simulation protocol. The technical approach is considered along with baseline flying quality ratings, the effect of sea state, the flying qualities rating boundaries, lateral control problems, and visual cues and texture. G.R.

**A86-27081**

**MATHEMATICAL MODELS FOR STUDYING AIRCRAFT VIBRATIONS WITH ALLOWANCE FOR STRUCTURAL HYSTERESIS [MATEMATICHESKIE MODELI DLIA ISSLEDOVANIIA KOLEBANII SAMOLETA S UCHETOM KONSTRUKTSIONNOGO GISTEREZISA]**

A. N. KOBTSEV IN: Energy dissipation connected with vibrations of mechanical systems . Kiev, Izdatel'stvo Naukova Dumka, 1985, p. 83-90. In Russian.

Mathematical models are presented which have been developed for the analysis of the dynamic loading of nonlinearly elastic aircraft during their arbitrary spatial motion. The models proposed here reproduce the nonlinear properties of the chassis and the internal damping of the aircraft structure. Some modeling results are presented, with particular attention given to the effect of hysteresis and damping parameters on the dynamic loading and fatigue damage of the airframes of several kinds of commercial aircraft. V.L.

**A86-27446**

**MATRIX EQUATIONS OF THE SPATIAL FLIGHT OF AN ASYMMETRICAL RIGID BODY [MATRICHNYE URAVNENIIA PROSTRANSTVENNOGO POLETA ASIMMETRICHNOGO TVERDOGO TELA]**

V. V. KRAVETS (Dnepropetrovskii Institut Inzhenerov Zheleznodorozhnogo Transporta, Dnepropetrovsk, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 22, Jan. 1986, p. 105-110. In Russian. refs

Matrix equations describing the dynamics of the spatial flight of an asymmetrical rigid body are proposed whose variables include quasi-velocities and the Rodrigues-Hamilton parameters. The dynamic equations and other auxiliary relationships are expressed in terms of unified matrices, which makes the equations well-organized, compact, and convenient in programming, providing for more efficient use of computers. V.L.

**A86-27659*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### EFFECTS OF SIDE-STICK CONTROLLERS ON ROTORCRAFT HANDLING QUALITIES FOR TERRAIN FLIGHT

E. W. AIKEN (NASA, Ames Research Center, U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 11 p. Previously announced in STAR as N85-25267. refs

Pertinent fixed and rotary-wing feasibility studies and handling-qualities research programs are reviewed and the effects of certain controller characteristics on handling qualities for specific rotorcraft flight tasks are summarized. The effects of the controller force-deflection relationship and the number of controlled axes that are integrated in a single controller are examined. Simulation studies were conducted which provide a significant part of the available handling qualities data. The studies demonstrate the feasibility of using a single, properly designed, limited-displacement, multiaxis controller for certain relatively routine flight tasks in a two-crew rotorcraft with nominal levels of stability and control augmentation with a high degree of reliability are incorporated, separated three or two-axis controller configurations are required for acceptable handling qualities. Author

**A86-27660#**

### THE DEVELOPMENT OF MICROCOMPUTER CODES FOR STUDYING THE FLIGHT DYNAMICS AND PERFORMANCE OF HELICOPTERS

B. W. MCCORMICK (Pennsylvania State University, University Park) and R. P. HENNIS (U.S. Navy, Naval Surface Weapons Laboratory, Dahlgren, VA) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 11 p.

A sequence of computer codes for predicting the dynamic behavior of a single rotor/tail rotor helicopter is described. Four basic codes are described, each of which can be run on current minicomputers. A static trim program calculates the control angles and the helicopter angle of attack, and a dynamic program numerically integrates the Euler equations of motion to fly a prescribed maneuver. A third program determines stability derivatives which are then used in the fourth program to analyze the helicopter stability. The latter program generates root loci as a function of stabilizing and control feedback gains. The programs include possible contributions from a stub wing and a horizontal tail with an angle of incidence which can be linked to the longitudinal cyclic pitch. Reasonable agreement is found between predicted results and flight tests simulating the launching of a ballistic rocket. C.D.

**A86-27662#**

### DYNAMIC STABILITY OF HINGELESS AND BEARINGLESS ROTORS IN FORWARD FLIGHT

I. CHOPRA (Maryland, University, College Park) and B. PANDA IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 16 p. refs (Contract DAAG29-83-K-0002)

The successful application of the finite element method based on Hamilton's principle to determine the response and dynamic stability of hingeless and bearingless rotor blades in forward flight is reported. Four beam elements were sufficient to obtain satisfactory response and stability solutions for a hingeless rotor blade, while six elements were needed for a bearingless rotor blade. For response normal mode equations, six rotating modes were adequate for both hingeless and bearingless blades. The vibratory amplitude and mean level of response depend on the advance ratio and the blade structural stiffness. Stability results are obtained for both soft-inplane and stiff-inplane rotors using elastic blade modeling. The effect of dynamic inflow on blade stability in hingeless and bearingless rotors is discussed. C.D.

**A86-27664#**

### KINEMATIC OBSERVERS FOR ROTOR CONTROL

R. M. MCKILLIP, JR. (Princeton University, NJ) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 10 p. refs

A simple scheme for estimating the state variables of a helicopter rotor is presented. The method incorporates the use of blade-mounted accelerometers and position transducers to reconstruct modal displacements and velocities. The design of the observer structure and feedback gains is simplified by the fact that the method requires only knowledge of simple kinematic relationships between the various modal quantities. This observer structure is particularly well-suited to control problems where the use of a traditional Kalman Filter would be too complex or costly. The technique can be viewed as decreasing the requirements on observer complexity while increasing the need for an enhanced sensor complement. Author

**A86-28377**

### QUANTITATIVE FEEDBACK DESIGN APPROACH TO PILOT-IN-THE-LOOP ANALYSIS

P. WEI (Lockheed-Georgia Co., Marietta, GA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 416-423.

The quantitative feedback technique of Horowitz et al. (1980) is applied, in conjunction with the Neal-Smith criterion, to the pilot-in-the-loop flight control system design. The uncertain control plants are developed by varying the pilot model parameters and pilot compensation work, and the boundaries of the system performance requirements are specified on the basis of the Neal-Smith criterion. As an example, a shaping filter is designed to improve the flying qualities from a possible Level 3 to a definite Level 1. I.S.

**A86-28378**

### DISCRETE MANEUVER FLYING QUALITIES CONSIDERATIONS IN CONTROL SYSTEM DESIGN

E. D. ONSTOTT and J. S. WARNER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 424-430. Research supported by Northrop Independent Research and Development Program. refs

An analysis of published NT-33 flight test data, a ground-based flight simulation, and time domain pilot/aircraft modeling techniques have shown that the criteria used in the established models may not be sufficiently responsive to the full range of piloted control activity. Large-amplitude, abrupt attitude changes must be specifically considered. An analytical method has been developed using parameters that describe discrete pilot activities. As an example, an actuator rate saturation problem is analyzed. I.S.

**A86-28379**

### DEVELOPMENT OF HARDWARE FOR X-29A FLIGHT CONTROL SYSTEM

J. DANNENHOFFER (Grumman Aerospace Corp., Bethpage, NY) and J. LINDAHL (Honeywell Inc., St. Louis Park, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 440-445. refs

The forward swept wing X-29 aircraft's sensor computer subsystem hardware maintains the lowest possible system costs through the use of off-the-shelf components. A triplex digital system together with triplex analog backup are used to satisfy fail-safe requirements, using extensive self-test and input/output comparisons to satisfy the requirements for a flight safety-oriented system. Attention is presently given to the methods by means of which system requirements were converted into the triplexed hardware, as well as to flightworthiness test results. O.C.

**A86-28380#**

**MULTIVARIABLE CONTROL LAW DESIGN FOR THE AFTI/F-16 WITH A FAILED CONTROL SURFACE**

R. A. ESLINGER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and J. J. DAZZO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 453-459. refs

The utilization of Porter's multivariable design technique (1981) to develop self-repairing flight control laws that allow the aircraft to maintain stability following a control surface failure is discussed. Linear state space models are created for a healthy F-16 aircraft and an F-16 with a free-floating right horizontal tail. The application of the Porter technique and the state equations to the model designs is described. The checking for transmission and decoupling zeros in the system with the computer program ZERO and the formation of control design laws with the program MULTI are examined. The responses of the models to longitudinal maneuvers (g-command, pitch pointing, and longitudinal translation) and lateral maneuvers (roll, sideforce, yaw pointing, and lateral translation) are evaluated. It is observed that the longitudinal and lateral maneuvers in the control surface failed aircraft are maintained with the control design laws applied to the models. It is concluded that the Porter method is useful in designing aircraft flight control systems which retain stability after control surface failure. I.F.

**A86-28384**

**AN INTEGRATED FLIGHT CONTROL SYSTEM FOR A STOL TRANSPORT AIRCRAFT**

P. BRIGGS, L. GARDNER (Sperry Corp., New York), and T. G. WOOD (Lockheed-Georgia Co., Marietta) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 482-489. refs

The development of a flight control system (FCS) for short takeoff and landing (STOL) aircraft using the High Technology Test Bed is studied. The main requirements for the future FCS are: (1) autonomous STOL capability, (2) automatic flight path control, (3) control reconfiguration, and (4) a ground-based maintenance diagnostics system; advances in these areas are discussed. The control of the spoilers and tail surface by the DFCS utilizing fail-operational roll stability and control augmentation, direct lift control, fail-operational yaw and pitch stability and control augmentation, and five dual electromechanical actuation systems is described. The input signal management, actuator signal management, synchronization, error handling, power-up reset and recovery, and the built-in test capabilities of the redundancy management of the DFCS are examined. The functional organization of the DFCS is explained. I.F.

**A86-28386**

**VARIABLE CONTROL POLICIES FOR FUTURE AEROSPACE VEHICLES**

F. R. GILL and K. W. ROSENBERG (GEC Avionics, Ltd., Rochester, England) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 500-506. refs

There exists a class of variable control policies with which all dynamic properties of a system are improved compared with the best achievable with conventional linear control. Examples of variable feedback and feedforward controllers are discussed and a new failure testing hypothesis is introduced. Author

**A86-28387**

**DESIGN OF DIRECT DIGITAL FLIGHT-MODE CONTROL SYSTEMS FOR HIGH-PERFORMANCE AIRCRAFT USING STEP-RESPONSE MATRICES**

B. PORTER (Salford, University, England) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 507-513. refs

(Contract SERC-GR/C/77653)

In this paper, fast-sampling error-actuated direct digital flight-mode control systems are designed for the F-16 aircraft using only the appropriate step-response matrix of the compensated open-loop aircraft instead of the first Markov parameter. It is shown that the resulting digital controllers exhibit set-point tracking characteristics which compare favorably with those of direct digital flight-mode controllers previously designed using a mathematical model of the aircraft in state-space form. Since step-response matrices can be readily determined from direct input-output measurements in the time domain, a basis is thus provided for the synthesis of adaptive self-repairing digital flight control systems operating in real time. Author

**A86-28392**

**DETECTION AND ISOLATION OF CONTROL SURFACE EFFECTIVENESS FAILURES IN HIGH PERFORMANCE AIRCRAFT**

J. L. WEISS, A. S. WILLSKY, D. P. LOOZE, J. T. CRAWFORD (ALPHATECH, Inc., Burlington, MA), and R. R. HUBER (General Electric Co., Aircraft Control Systems Dept., Binghamton, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 552-559. refs

This paper presents the design of a failure detection and identification (FDI) algorithm for flight control system failures. This algorithm, which is a key component in an overall fault-tolerant control strategy, is based on analytic redundancy and follows the decentralized philosophy which was originally developed and applied to dual redundant sensor FDI systems on the F-8 aircraft. This philosophy, which is generalized and extended here, addresses the problems associated with 'real-world' model errors. Test results using a nonlinear six-degree-of-freedom aircraft simulation are presented to demonstrate the algorithm's performance. Author

**A86-28393**

**EVALUATION OF CONTROL MIXER CONCEPT FOR RECONFIGURATION OF FLIGHT CONTROL SYSTEM**

K. S. RATTAN (Wright State University, Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 560-569. refs

(Contract F49620-82-C-0035)

Reconfiguration of flight control law after effector failure is studied in this paper. The objective of this paper is to evaluate the control mixer concept which utilizes generalized inverse to distribute control authority among the remaining effectors after failure. The unmanned research vehicle (URV) was selected as a test bed for evaluating this concept. A mathematical model containing split surfaces and linearized equations of motion for coupled longitudinal and lateral-direction axes is developed. Control mixer gain matrices are obtained for failed surfaces and a comparison of the unimpaired and reconfigured aircraft responses is made using the Continuous System Modeling Program (CSMP). Difficulties encountered with the generalized inverse based control mixer concept are discussed. Author

A86-28394* Alphatech, Inc., Burlington, Mass.

**AN AUTOMATIC REDESIGN APPROACH FOR RESTRUCTURABLE CONTROL SYSTEMS**

D. P. LOOZE, J. L. WEISS, J. S. ETERNO, and N. M. BARRETT (ALPHATECH, Inc., Burlington, MA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 570-577. refs

(Contract NAS1-17411)

This paper presents an approach to the automatic redesign of flight control systems for aircraft that have suffered one or more control element failures. The procedure is based on Linear Quadratic design techniques, and produces a control system that maximizes a measure of feedback system performance subject to a bandwidth constraint. Author

A86-28395

**YF16CCV FLIGHT CONTROL SYSTEM RECONFIGURATION DESIGN USING QUANTITATIVE FEEDBACK THEORY**

I. HOROWITZ (Weizmann Institute of Science, Rehovot, Israel), P. B. ARNOLD (USAF, Test Pilot School, Edwards AFB, CA), and C. H. HOUPIS (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 578-585. refs

A fixed compensation design theory is presented for achieving flight control performance, despite one or more simultaneous failures, hardover and varying flight conditions. No identification is used. The theory is a natural extension of Quantitative Feedback Theory (QFT) for uncertain systems, and clearly reveals the cost of feedback needed. This enables the designer to make intelligent trade-offs between fixed compensation, scheduling and identification-adaptation. Identification, when it is necessary, can be done more slowly and accurately if a QFT design is made so the system is at least stable over many simultaneous failures. The theory is applied to the YF16CCV model with elevators and flaperons for pitch and roll rate control. Author

A86-28396

**LOCKHEED-GEORGIA AND ELECTRIC PRIMARY FLIGHT CONTROL SYSTEMS**

K. THOMPSON, R. ALDEN (Lockheed-Georgia Co., Marietta), and L. HUNTER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 588-595. refs

The designs of various electric actuation systems (EASs) are studied. The components and functions of the C-141 dual channel EAS for the aileron are described. The system operation/fault monitoring of the two channels of the EAS are examined. The performance capabilities of the EAS are compared to a hydraulic power control actuation system. The utilization of EASs to improve STOL capabilities, aircraft survivability, flight stations, and integrated control and avionics is being studied in the High Technology Test Bed program. The development of an electric rudder tab control actuation system and a yaw stability and control augmentation system is analyzed. I.F.

A86-28401

**MICROPROCESSOR CONTROLLED AND MANAGED FLY-BY-WIRE HYDRAULIC ACTUATOR**

C. C. CHENOWETH and D. B. SLAUGH (Boeing Military Airplane Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 628-632.

During the past few years, the greatest technological advances in the aerospace industry have been associated with aircraft flight controls. In connection with these advances, mechanical systems are being replaced by fly-by-wire systems in which the pilot is linked to an array of actuators through a central aircraft control computer complex. A new actuation technology development is presented, taking into account the use of microprocessor-based actuation controllers communicating with aircraft-control computers over digital data buses. Attention is given to the advantages of fly-by-wire systems, aspects of smart actuator development, and future plans. G.R.

A86-28490* E-Systems, Inc., Dallas, Tex.

**AN EXPERT PLANNER FOR THE DYNAMIC FLIGHT ENVIRONMENT**

D. C. CHEN (E-Systems, Inc., Garland Div., Dallas, TX) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1347-1354. refs

(Contract NAG1-288; F49620-82-K-0009)

This paper presents a robust robot planner that functions in the complex and dynamic flight domain. The robot pilot flies an aircraft between two airports and can adjust in flight to changes in the environment such as closed destination airport, thunderstorm in the flight path, and failed engine. The planner adjusts to the world changes by locally patching around the break point instead of complete replanning. The planning architecture is based on the vertical decomposition of domain knowledge, resulting in shallow planning and recovery planning. This robot flight planner can be utilized as the front end of an intelligent flight monitor. The flight planner dynamically generates the references that are used to determine whether the flight crew should be notified of potential problems. The implementation of this robot planner is also discussed. Author

A86-28498

**KNOWLEDGE ENGINEERING FOR A FLIGHT MANAGEMENT EXPERT SYSTEM**

B. M. ANDERSON, J. M. BEAL, C. MCNULTY, and R. C. STERN (Texas Instruments, Inc., Dallas) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1431-1435. refs

The development of an F-16 emergency procedures knowledge base for EPES (emergency procedures expert system) is described. A detailed view of the knowledge acquisition problems is presented, followed by a methodology for efficiently building a knowledge base for emergency procedures. A multiple emergency example is considered (loss of canopy and towershaft failure while cruising at 400 knots above 40,000 feet), where the inference engine resolves a conflict in procedures. D.H.

A86-28499#

**PATH-FINDER - AN HUERISTIC APPROACH TO AIRCRAFT ROUTING**

C. S. LIZZA and G. LIZZA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1436-1443. refs

A solution is examined for the problem of developing an effective computer algorithm to route aircraft through hostile enemy defenses. The problem was proposed to assist in studies of the impact of varied, onboard countermeasures upon preplanned aircraft routes. The quality of a route can be defined in terms of the cost of interaction between the aircraft and threats encountered along the path. Current methods of automated routing are either inefficient or produce unsatisfactory results. Beginning with a more general description of the problem, a solution is detailed for developing routes by using the AI technique of heuristic search in an A(asterisk) algorithm. The algorithm uses heuristics based upon estimates of the degree of threat interactivity and distance from a point to the goal. Due to the nature of the heuristic, the A(asterisk) algorithm cannot guarantee development of a least-cost path, but the heuristic can be adjusted to ensure reasonably good results in most cases. The flexibility of the algorithm allows application to the specific aircraft routing problem and to other route planning tasks. D.H.

**A86-28509**

**FLYING QUALITIES DESIGN CRITERIA FOR HIGHLY AUGMENTED SYSTEMS**

D. J. MOORHOUSE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and W. A. MORAN (McDonnell Aircraft Co., St. Louis, MO) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1536-1545. refs

Interpretation and application of the military flying qualities specification, MIL-F-8785C, as the best guide to excellent flying qualities, is suggested. A summary is given of the government's flight control requirements of the Statement of Work of the STOL and Maneuver Technology Demonstration Program (SMTDP). The program contractor, McDonnell Aircraft Company, has had recent experience developing the digital flight control system of the F/A-18A. Lessons learned from that development are used to define the appropriate interpretations of specific requirements in MIL-F-8785C. These are expressed as preliminary detailed flying qualities criteria for the SMTDP, plus 'second tier' criteria to be used for additional design guidance. D.H.

**A86-28510#**

**MULTIVARIABLE CONTROL LAW DESIGN FOR THE X-29 AIRCRAFT**

J. J. DAZZO and T. L. COURTHEYN (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1546, 1547.

Flight control laws have been developed for the X-29 forward swept wing demonstrator aircraft, using a design technique based on a multivariable control law theory. The computer-aided design program called MULTI is used to develop and refine the control laws. MULTI also simulates the complete closed-loop control system and generates appropriate time response plots for analysis. Control laws are developed to stabilize the aircraft and to perform longitudinal maneuvers (direct climb, vertical translation, and pitch pointing) at three different flight conditions. The use of a proportional plus integral control law for a digital output feedback flight control system produced very good performance. The ability to incorporate actuator dynamics and computational time delay in the control law generation adds to the design capability. Investigation of further applications is warranted. D.H.

**A86-29058**

**ADVANCING FLIGHT CONTROL TECHNOLOGY**

H. BERMAN (Grumman Aerospace Corp., Bethpage, NY) Horizons (ISSN 0095-7615), vol. 21, no. 3, 1985, p. 14-21.

The development of fly-by-wire (FBW) controls for aircraft has been driven by the need to augment the muscular power expended by pilots to control their aircraft, to provide increasingly greater maneuverability, and to lower the weight penalty of the control mechanisms. The X-29, with a 35 percent negative margin of static stability, is the cutting edge of FBW technology. The reduced stability of the X-29 furnishes the desired enhanced maneuverability, and can only work if the aircraft is continuously under computer control. The X-29 stability is maintained by control adjustment inputs at 40 times per second in a manner transparent to the pilot. The computer is fed a constant stream of flight status data which is analyzed to make the control decisions by means of a polling procedure among three on-board computers. The forward swept supercritical wings of the X-29 are equipped with two-segment trailing edge flaps that make the wings variable camber so the computers can vary the lift/drag characteristics of the wings in-flight. The experimental aircraft is also serving as a testbed for reconfigurable controls which would compensate for the presence of damaged control surfaces, for an automated approach fine-tuning system, and for examining supermaneuverability at flight speeds into the transonic. M.S.K.

**N86-20397*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AIRPLANE AUTOMATIC CONTROL FORCE TRIMMING DEVICE FOR ASYMMETRIC ENGINE FAILURES Patent application**

E. C. STEWART, inventor (to NASA) 23 Oct. 1985 14 p (NASA-CASE-LAR-13280-1; NAS 1.71:LAR-13280-1; US-PATENT-APPL-SN-790556) Avail: NTIS HC A02/MF A01 CSCL 01C

The difference in dynamic pressure in the propeller slipstreams as measured by sensors is divided by the freestream dynamic pressure generating a quantity proportional to the differential thrust coefficient. This quantity is used to command an electric trim motor to change the position of trim tab thereby retrimming the airplane to the new asymmetric power condition. The change in position of the trim tab produced by the electric trim motor is summed with the pilot's input to produce the actual trim tab position. NASA

**N86-20399#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.

**FAULT TOLERANT HARDWARE/SOFTWARE ARCHITECTURE FOR FLIGHT CRITICAL FUNCTION**

Loughton, England Sep. 1985 146 p refs Lecture series held at Edwards AFB, Calif., 1-2 Oct. 1985, in Copenhagen, Denmark, 17-18 Oct. 1985, and in Athens, Greece, 21-22 Oct. 1985 (AGARD-LS-143; ISBN-92-835-1510-2) Avail: NTIS HC A07/MF A01

This Lecture Series is intended to provide basic concepts and theories in the design of fault-tolerant architectures for flight critical systems. It is intended to cover experience with flight tested fly-by-wire systems as well as issues in redundancy management of synchronous and asynchronous approaches. It will specifically address the individual aspects of software fault tolerance, actuation fault tolerance, reliable data communication, and multi-computer operation using the Ada language.

**N86-20400#** Honeywell Systems and Research Center, Minneapolis, Minn.

**INTRODUCTION TO LECTURE SERIES NO. 143: FAULT TOLERANT HARDWARE/SOFTWARE ARCHITECTURES FOR FLIGHT CRITICAL FUNCTIONS**

G. L. HARTMANN *In* AGARD Fault Tolerant Hardware/Software Architecture 3 p Sep. 1985 refs Avail: NTIS HC A07/MF A01

Modern weapon systems, driven by escalating performance demands, are becoming complex and sophisticated. Demands for higher accuracy, improved reliability/survivability, all-weather operation, and more automation are placing increased emphasis on the control function. Nowhere is this increased emphasis more evident than in the control functions required in advanced aircraft systems. Due to the expanded role of automation many functions are becoming flight-critical (i.e., loss of this function is catastrophic). Flight critical architectures are more complex than fault-tolerant computers. In addition to airborne computers, overall reliability depends on proper design and management of: (1) Sensors and their interfaces; (2) Actuation elements; and (3) Data communication along the distributed elements. Previous NATO-AGARD publications have dealt with related aspects of this subject. This lecture series covers experience with flight tested fly-by-wire systems as well as issues in redundancy management of synchronous and asynchronous systems. It specifically addresses software fault tolerance, actuation fault tolerance, reliable data communications, and multi-computer operation using the Ada language. Author

**N86-21549*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STEP AND STEPSPL: COMPUTER PROGRAMS FOR AERODYNAMIC MODEL STRUCTURE DETERMINATION AND PARAMETER ESTIMATION**

J. G. BATTERSON Jan. 1986 142 p refs
(NASA-TM-86410; NAS 1.15:86410) Avail: NTIS HC A07/MF A01 CSCL 01C

The successful parametric modeling of the aerodynamics for an airplane operating at high angles of attack or sideslip is performed in two phases. First the aerodynamic model structure must be determined and second the associated aerodynamic parameters (stability and control derivatives) must be estimated for that model. The purpose of this paper is to document two versions of a stepwise regression computer program which were developed for the determination of airplane aerodynamic model structure and to provide two examples of their use on computer generated data. References are provided for the application of the programs to real flight data. The two computer programs that are the subject of this report, STEP and STEPSPL, are written in FORTRAN IV (ANSI 1966) compatible with a CDC FTN4 compiler. Both programs are adaptations of a standard forward stepwise regression algorithm. The purpose of the adaptation is to facilitate the selection of a adequate mathematical model of the aerodynamic force and moment coefficients of an airplane from flight test data. The major difference between STEP and STEPSPL is in the basis for the model. The basis for the model in STEP is the standard polynomial Taylor's series expansion of the aerodynamic function about some steady-state trim condition. Program STEPSPL utilizes a set of spline basis functions. Author

**N86-21550*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF WING MODIFICATION ON AN AIRCRAFT'S AERODYNAMIC PARAMETERS AS DETERMINED FROM FLIGHT DATA**

R. A. HESS Jan. 1986 72 p refs
(NASA-TM-87591; NAS 1.15:87591) Avail: NTIS HC A04/MF A01 CSCL 01C

A study of the effects of four wing-leading-edge modifications on a general aviation aircraft's stability and control parameters is presented. Flight data from the basic aircraft configuration and configurations with wing modifications are analyzed to determine each wing geometry's stability and control parameters. The parameter estimates and aerodynamic model forms are obtained using the stepwise regression and maximum likelihood techniques. The resulting parameter estimates and aerodynamic models are verified using vortex-lattice theory and by analysis of each model's ability to predict aircraft behavior. Comparisons of the stability and control derivative estimates from the basic wing and the four leading-edge modifications are accomplished so that the effects of each modification on aircraft stability and control derivatives can be determined. Author

**N86-21551#** Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.

**LIMITING PERFORMANCE OF NONLINEAR SYSTEMS WITH APPLICATIONS TO HELICOPTER VIBRATION CONTROL Final Report, 1 Aug. 1982 - 31 Oct. 1984**

W. D. PILKEY Aug. 1985 9 p
(Contract DAAG29-82-K-0164)
(AD-A161457; ARO-18643.10-EG) Avail: NTIS HC A02/MF A01 CSCL 20K

Several problems concerning the vibration control of helicopters were studied. A method for introducing structural modifications leading to vibration reduction has been developed. In particular, a formulation for attaching appendages to continuous structural members was completed and applied to a two-beam helicopter model. Author (GRA)

**N86-21553#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Forschungsbereich Flugmechanik/Flugfuehrung.

**A CONTRIBUTION TO THE DIGITAL COMPENSATION OF PERIODIC DISTURBANCES WITH FREQUENCIES IN BOUNDED INTERVALS Ph.D. Thesis - Technische Univ., Berlin, West Germany**

R. FRORIEP Sep. 1985 141 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-979)
(DFVLR-FB-85-55; ISSN-0171-1342) Avail: NTIS HC A07/MF A01; DFVLR, Cologne DM 45.50

A general design method for the simplest possible compensator was developed in order to satisfy the requirement of stationary disturbance compensation within given tolerance limits for all helicopter rotor speeds within a given bounded interval. The approach to the suppression of rotor induced vibrations is to suspend the fuselage from the rotor by electrohydraulic actuators. Using a digital computer the most dominant harmonics of the disturbance can be actively compensated. For compensation at sampling instants, a structure of a digital controller is introduced and motivated, in which a minimal number of parameters is adapted to a varying rotor speed. The remaining parameters are to be held constant during operation independent of rotor speed. In the design, these parameters are systematically improved with a multidisturbance model approach and a design methodology with vector performance index. For disturbance suppression between sampling instants a design method for impulse forming filters is proposed. Author (ESA)

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-28278**

**FUTURE APPLICATIONS AND PROSPECTS FOR FLIGHT SIMULATION; PROCEEDINGS OF THE SPRING CONVENTION, LONDON, ENGLAND, MAY 9, 10, 1984**

Convention sponsored by the Royal Aeronautial Society. London, Royal Aeronautical Society, 1985, 134 p. No individual items are abstracted in this volume.

The present conference on prospective developments in the field of flight simulation considers the upgrading of simulator technology, the changing role of supplemental simulators, applications of air combat simulation to pilot training, Line Orientation Flight Training inflight simulation, and the development status and future potential of training management systems. Also discussed are human factors and the use of the image visual system to meet training requirements, fiber-optic helmet-mounted displays, AV-8B (Harrier II) training capabilities, B-757/767 program engineering development simulators, third-generation digital flight controls, a military view of future flight simulation capabilities, and the use of simulators in the U.S. Navy's T-45 jet trainer integrated system for carrier aircraft pilots. O.C.

**A86-28457#**

**LOW COST PART TASK TRAINER FOR THE GBU-15 GUIDED BOMB**

J. W. ACKERSON and D. W. RUCK (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1068-1073.

The design and development of an interim part task trainer for the GBU-15 standoff precision attack weapon system for the destruction of fixed targets is described. Using either electro-optical or infrared images transmitted by RF datalink signals, an operator in either in the delivery aircraft or another aircraft guides the bomb to the target. Each trainer, controlled by a microcomputer, generates the required imagery from a photographic filmplate. The benefits of this approach are short development time, minimal manpower requirements, and development of baseline information for future procurement of a more powerful trainer. Author

**A86-28458**
**MODULAR SIMULATORS - A COMPREHENSIVE UNIFIED ARCHITECTURE**
S. SEIDENSTICKER (Logicon, Inc., Tactical and Training Systems Div., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1074-1079.

Various aspects are explored for a comprehensive unified modular approach to design, construction, and procurement of flight simulators. Issues addressed include module definition, interface specification, implementation approaches, standards, and potential impact on technology. At the heart of the architecture is a universal interface that interconnects all modules; this interface is embodied in a high capacity Local Area Network (LAN). D.H.

**A86-28459**
**MODULAR SIMULATORS - HOW TO MAKE IT WORK**
M.-E. HECKER (Logicon, Inc., Tactical and Training Systems Div., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1080-1085.
(Contract F33657-83-C-2201)

Factors to be considered in building complex modular simulators are examined. The functions of simulators are divided among carefully defined modules, which may each come from a different vendor. The modules must both send and receive messages necessary for running of their respective modeling and environmental simulation programs. Interfaces must be standardized and not require unique design or contractor proprietary information. Flexibility to incorporate good new engineering developments at a late stage is necessary. To accomplish such a complex task, there must be defined from the outset a central authority (to control module and message definition), a separate support module (which functions specifically to monitor logistics and support), and a users' group (to explore new ideas and exchange findings). D.H.

**A86-28460**
**MODULAR SIMULATORS - IS A LOCAL AREA NETWORK SUFFICIENT?**
D. L. JOHNSTON (Logicon, Inc., Tactical and Training Systems Div., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1086-1093. refs
(Contract F33657-83-C-2201)

A local area network, Ethernet, is examined for its use in modular flight simulators. A computer model of a data communication network is developed to assess the capacity and timing of Ethernet. Estimates of the communication requirements for modular configurations of T-37 and F-16 simulators are used with the network model. The results show that Ethernet will easily transfer the data required for real-time operation by these simulator configurations. Author

**A86-28462**
**INSTRUCTOR STATION FOR THE ILLIMAC GENERAL AVIATION INSTRUMENT TRAINING SIMULATOR**
H. L. TAYLOR, F. C. HYMAN, R. E. TODD, and A. S. HODEL (Illinois, University, Urbana) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1111-1118.

A software program that permits a standard computer terminal to be used as an instructor station was developed for the University of Illinois Micro Aviation Computer (ILLIMAC) simulator. A split screen format was used to display menus, from which instrument training scenarios could be developed, and to display information on the current status of the instructor inputs to the simulator. A training manual was developed to provide self-paced instruction on the operation of the instructor station. Twelve flight instructors evaluated the effectiveness of the training manual and the instructor station. Results indicated that scenarios could be entered without assistance with a minimum error rate after about one hour self-paced training. Response to a questionnaire on the effectiveness of the training program and the instructor station was very positive. Author

**A86-28560#**
**DIRECT DERIVATIVE MEASUREMENTS IN THE PRESENCE OF STING PLUNGING**
M. E. BEYERS (National Research Council of Canada, Ottawa) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 179-185. Previously cited in issue 20, p. 2856, Accession no. A84-42355. refs

**A86-28561*#** Vigyan Research Associates, Inc., Hampton, Va.
**NUMERICAL SIMULATION OF A CONTROLLED-FLOW TUNNEL FOR V/STOL TESTING**
P. C. PARIKH (Vigyan Research Associates, Inc., Hampton, VA) and R. G. JOPPA (Washington, University, Seattle) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 186-191. Previously cited in issue 20, p. 2856, Accession no. A84-41330. refs
(Contract NSG-2260)

**N86-20410#** Federal Aviation Administration, Washington, D.C.
**OBSTRUCTION MARKING AND LIGHTING**
Oct. 1985 66 p
(AC-70/7460-1G) Avail: NTIS HC A04/MF A01

The Federal Aviation Administration's (FAA) standards for marking and lighting of obstructions as identified by FAA regulations part 77, are desribed. Provision's for marking and lighting wind turbines, towers, and moored balloons are given. R.J.F.

**N86-21555#** New Mexico Univ., Albuquerque.
**RUBBER REMOVAL SPECIFICATION DEVELOPMENT Final Report, May 1983 - Sep. 1985**
R. A. GRAUL, L. R. LENKE, and D. L. STANDIFORD Oct. 1985 56 p refs Prepared in cooperation with Air Force Engineering Services Center, Tyndall AFB, Fla.
(Contract F29601-84-C-0080)
(FAA/PM-85/33; ESL-TR-85-67) Avail: NTIS HC A04/MF A01

The phenomenon of runway touchdown-zone rubber buildup is a potentially hazardous problem. Rubber buildup covers the runway surface and occludes the surface texture. This results in a reduced wet friction coefficient between the runway pavement and aircraft tires. Methods and equipment are available for evaluating the wet friction coefficient; however, these methods are expensive and require highly trained personnel. Currently, no guidelines have been established for determining the need and effectiveness of rubber removal. Therefore, most airport and airbase managers rely exclusively on visual impressions of rubber buildup in lieu of quantitative measurements. Quantitative evaluation techniques are desirable for evaluating rubber buildup. An extensive literature review suggested that pavement surface texture measurement techniques are indicative of rubber buildup and resultant reduction in wet friction coefficients. A statistically designed field experiment

determined that surface texture measurements were indicative of pavement friction levels; however, these relationships lacked the precision necessary for inclusion in performance specifications.
Author

**N86-21556#** New Mexico Univ., Albuquerque. Engineering Research Inst.
**RUNWAY RUBBER REMOVAL SPECIFICATION DEVELOPMENT Final Report, May 1983 - Sep. 1985**
R. A. GRAUL, L. R. LENKE, and D. L. STANDIFORD Oct. 1985 56 p refs Prepared in cooperation with Air Force Engineering and Services Center, Tyndall AFB, Fla.
(Contract F29601-84-C-0080)
(DOT/FAA/PN-85/33; ESL-TR-85-67) Avail: NTIS HC A04/MF A01

The phenomenon of runway touchdown-zone rubber buildup is a potentially hazardous problem. Rubber buildup covers the runway surface and occludes the surface texture. This results in a reduced wet friction coefficient between the runway pavement and aircraft tires. Methods and equipment are available for evaluating the wet friction coefficient; however, these methods are expensive and require highly trained personnel. Currently, no guidelines have been established for determining the need and effectiveness of rubber removal. Therefore, most airport and airbase managers rely exclusively on visual impressions of rubber buildup in lieu of quantitative measurements. Quantitative evaluation techniques are desirable for evaluating rubber buildup. An extensive literature review suggested that pavement surface texture measurement techniques are indicative of rubber buildup and resultant reduction in wet friction coefficients. A statistically designed field experiment determined that surface texture measurements were indicative of pavement friction levels; however, these relationships lacked the precision necessary for inclusion in performance specifications. A summary of previous work in developing a rubber removal specification, supporting evidence for the frictional performance criteria proposed in developing a coherent specification for rubber removal contracts, and proposed contract specification criteria for runway rubber removal are given.
Author

## 10

## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-28802**
**DIRIGIBLE AIRSHIPS FOR MARTIAN SURFACE EXPLORATION**
W. M. CLAPP (MIT, Cambridge, MA) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 489-496. refs
(AAS 84-176)

A balloon, an aeroplane, and a dirigible were analyzed to determine their flight performance on Mars. The dirigible proved to offer the highest payload fraction of the three systems, which were designed for a total lift of 1000 kg and a range of 100 nautical miles. In addition, the dirigible offered several operational advantages in the Mars environment.
Author

**N86-20485*#** Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.
**VIBRATIONS AND STRUCTUREBORNE NOISE IN SPACE STATION Progress Report, 1 Jul. - 31 Dec. 1985**
R. VAICAITIS 31 Dec. 1985 119 p refs
(Contract NAG1-541)
(NASA-CR-176520; NAS 1.26:176520) Avail: NTIS HC A06/MF A01 CSCL 22B

Theoretical models were developed capable of predicting structural response and noise transmission to random point mechanical loads. Fiber reinforced composite and aluminum materials were considered. Cylindrical shells and circular plates were taken as typical representatives of structural components for space station habitability modules. Analytical formulations include double wall and single wall constructions. Pressurized and unpressurized models were considered. Parametric studies were conducted to determine the effect on structural response and noise transmission due to fiber orientation, point load location, damping in the core and the main load carrying structure, pressurization, interior acoustic absorption, etc. These analytical models could serve as preliminary tools for assessing noise related problems, for space station applications.
Author

## 11

## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-26326**
**CONFERENCE ON STEELS AND SPECIAL ALLOYS IN AERONAUTICS, 11TH, LE BOURGET, FRANCE, JUNE 6, 1985, PROCEEDINGS [COLLOQUE SUR LES ACIERS ET LES ALLIAGES SPECIAUX DANS L'AERONAUTIQUE, 11TH, LE BOURGET, FRANCE, JUNE 6, 1985, PROCEEDINGS]**
Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, 158 p. In French and English. For individual items see A86-26327 to A86-26338.

Three different development status assessments are presented by leading industry representatives for French advancements in the formulation and processing of aircraft specialty steels, aluminum alloys, and titanium alloys. Performance comparisons are persistently made in view of continuing improvements in the field of advanced organic matrix composites, especially those composites reinforced with continuous carbon fibers. The meeting at which these evaluations were made covered new developments in airliner, helicopter, and spacecraft structures, novel primary aircraft structure materials, landing gear metals, the evolution of turbine blade materials, single crystal superalloys for gas turbine blades, turbofan thrust reverser materials, novel aluminum alloys, trends in Ti alloy processing technology development, thermomechanical processing during closed dye forging, and high strength stainless steels.
O.C.

**A86-26327**
**NEW DEVELOPMENTS IN THE MATERIALS USED IN AIRLINER, HELICOPTER AND SPACECRAFT STRUCTURES [EVOLUTION DES MATERIAUX UTILISES DANS LES STRUCTURES DES AVIONS, HELICOPTERES ET ENGINS]**
J. ODORICO (Aerospatiale, Paris, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 531-539. In English and French.

A development status and development trend evaluation is undertaken for advanced materials applicable to commercial aircraft, helicopter and spacecraft primary structures. In the case of high strength steels, little developmental success is seen in recent work which is (which is primarily concerned with damage tolerance); by contrast, promising trends are noted in superplastic forming/diffusion bonding techniques for titanium alloys. Especially encouraging are activities in the formulation of novel aluminum alloys employing additions of zinc, copper, and lithium, and in the application of bonded aluminum sheet/aramid fiber laminates (Arall). Attention is given to performance gains over metallic materials that are obtainable by means of carbon fiber-reinforced plastics. O.C.

**A86-26328**

**WHAT DOES THE FUTURE HOLD FOR 1990'S NEW AIRFRAME MATERIALS [LA PLACE DES MATERIAUX NOUVEAUX DANS LES CELLULES D'AVIONS DES ANNEES 1990]**

D. CHAUMETTE (Avions Marcel Dassault-Breguet Aviation, Vaucresson, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 541-546. In English and French.

Development trends are projected into the 1990s for the application of advanced steels, aluminum alloys such as aluminum-lithium, titanium, and carbon or kevlar fiber-reinforced composites, to the construction of a major French manufacturer's aircraft. It is noted that aluminum-lithium alloys' attractiveness is detracted from by their appearance at the very moment when second-generation carbon fibers (for polymer matrix reinforcement) with markedly improved strength and rigidity are becoming commercially available. Predictions are made for prospective usage of these materials in combat aircraft such as the Rafale fighter, business aircraft, and the Hermes spacecraft. O.C.

**A86-26329**

**DEVELOPMENT OF MATERIALS USED IN LANDING GEAR [EVOLUTION DES MATERIAUX DANS LES ATTERRISSEURS]**

G. HENAULT (Messier-Hispano-Bugatti, Montrouge, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 547-558. In English and French.

In aircraft landing gear fabrication, semifinished castings and forgings of precisely formulated materials may represent as much as 40 percent of the cost of the finished component after machining and assembly. The present evaluation of the development status and trends in this industry notes no revolutionary developments or prospects; steels will remain the primary materials for landing gear applications. The high strength 7000-series alloys are in more general use, and 7010-T736 has been chosen for further development. Ti alloys and composites are not expected to make substantial inroads into landing gear design. O.C.

**A86-26330**

**THE EVOLUTION OF TURBINE BLADE MATERIALS [L'EVOLUTION DES MATERIAUX POUR AUBES DE TURBINE]**

J.-P. HERTEMAN (SNECMA, Paris, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 559-566. In English and French. refs

The joint development of precision investment casting processes and of high creep strength/low work hardening rate materials has been a primary factor in the continuing increase of aircraft gas turbine inlet temperatures. The development of single crystals, oxide dispersion-strengthened, and oriented eutectic alloys has been especially fruitful. Significant advancements are expected in the case of single crystal alloys, through a gradual reduction of specific gravity, which will reduce the stresses currently borne by turbine disks. O.C.

**A86-26332**

**MATERIALS IN THRUST REVERSERS [LES MATERIAUX DANS LES INVERSEURS DE POUSSEE]**

G. LADOUX (Hispano-Suiza, Saint-Cloud, France), R. CAMEO (Microfusion, S.A., Gennenvilliers, France), and J. BARILLOT-CREUZET (Ets Robert Creuzet Sarl, Marmande, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 579-584. In English and French.

The design features of contemporary high bypass turbofan thrust reverser mechanisms, which are integral parts of the engine cowl paneling, are presently discussed with a view to the materials and fabrication technologies that satisfy such devices' performance criteria. Steel have limited use in fasteners and hydraulic tubing. Aluminum alloys constitute the largest portion of material used, with the remainder made up of epoxy-matrix composite materials. Aluminum elements are fabricated from forged blocks, thick sheet metal, precision castings, thin sheet honeycomb cores, pressings, superplastically formed plates, and extrusions. Carbon/epoxy composite paneling is essential for noise-control purposes. O.C.

**A86-26334**

**THE NEW ALUMINIUM ALLOYS FOR THE AERONAUTICAL INDUSTRY [LES NOUVEAUX ALLIAGES D'ALUMINIUM POUR L'AERONAUTIQUE]**

P. MEYER (Cegedur Pechiney, Centre de Recherche et Developpement de Voreppe, France) and S. DERMARKAR (Cegedur Pechiney, Department Techniques Avancees, Paris, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 593-601. In English and French.

A development status and prospective structural performance evaluation is presented for recent advancements in the field of aircraft aluminum aloys that encompass Al-Li alloys, powder metallurgy alloys, and aluminum-matrix composites. The four Al-Li alloys in question, designated CP 271, 274, 276, and 277, respectively offer density reductions of 10, 8, 8, and 12 percent over conventional aircraft alloys. Attention is given to the performance improvements obtainable by means of short and long fiber reinforcement of aluminum alloy matrices, especially with respect to specific elastic modulus and specific ultimate tensile strength. O.C.

**A86-26337**

**THE DEVELOPMENT OF HIGH STRENGTH STAINLESS STEELS FOR THE AERONAUTICAL INDUSTRY [EVOLUTION DES ACIERS INOXYDABLES A HAUTE RESISTANCE POUR CONSTRUCTION AERONAUTIQUE]**

R. RAVEZ (Acieries Aubert et Duval, S.A., Neuilly-sur-Seine, France), M. DELARBOULAS, and R. COZAR (Imphy, S.A., Paris-la-Defense, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 619-621. In English and French.

An account is given of the development history of high strength stainless steels possessing good drop forge-shaping ductility, which facilitates the production of aircraft structural components. Attention is given to maraging stainless steels from which the carbides and ferrite that compromise ductility in other formulations can be entirely eliminated. The engine nacelle strut of the A 320 airliner has been fabricated from such a steel; histograms of dispersions obtained during acceptance tests for these components are presented. Tensile strenths are of the order of 1200-1250 MPa. O.C.

**A86-26338**

### PROPERTIES AND POTENTIAL AEROSPACE APPLICATIONS OF E Z 3 CNDA 13-08 STEEL. II [CARACTERISTIQUES ET POSSIBILITES D'APPLICATIONS AEROSPATIALES DE L'ACIER E Z 3 CNDA 13-08]

M. DELARBOULAS and R. COZAR (Imphy, S.A., Paris-la-Defense, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 622-631. In English and French. refs

The precipitation-hardened martensitic stainless steel E Z 3 CNDA 13-08, heat-treated to yield strength levels above 1 150 MPa is becoming increasingly attractive for aerospace applications. Improved understanding of the underlying metallurgy has led to greater control over melting and processing, resulting in better strength-toughness combinations. Potential aerospace applications are illustrated by both experimental results and industrially produced components. Author

**A86-27084**

### THE DAMPING CAPACITY OF LAYERED MATERIALS [DEMPFIRUIUSHCHAIA SPOSOBNOST' SLOISTYKH MATERIALOV]

V. N. VIAKIN, G. G. KARTASHOV, N. S. KONDRASHOV, and V. I. SUSLIKOV IN: Energy dissipation connected with vibrations of mechanical systems . Kiev, Izdatel'stvo Naukova Dumka, 1985, p. 215-225. In Russian. refs

The paper reports the results of an experimental study of the damping properties of layered materials consisting of a combination of adhesives and sealants with metal layers or with layers of metal and nonmetal composites. On the basis of the results obtained, the damping properties of a titanium-base sound-absorbing material have been improved by saturating it with a viscoelastic filler, and efficient sound-absorbing structures have been developed by using composite materials. The results of the study are currently used for developing shells and enclosures for gas-turbine engines. V.L.

**A86-27198**

### STRENGTH PROFILE IN AL-LI PLATE MATERIAL

M. PETERS, J. ESCHWEILER, and K. WELPMANN (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) Scripta Metallurgica (ISSN 0036-9748), vol. 20, Feb. 1986, p. 259-264. refs

An explanation is sought for an anisotropic strength profile seen in low-density, high-stiffness Al-Li alloys, in plate form, where tensile properties showed a variation through the plate thickness. The alloy investigated was DTD XXXA with a nominal composition in weight percent of Al-2.5Li-1.2Cu-0.7Mg-0.12Zr. The results suggest that the strong strength gradient observed is primarily due to texture hardening. (111) pole figures are given for DTD XXXA and 2024 plate material for comparison purposes. D.H.

**A86-27201**

### TITANIUM: SCIENCE AND TECHNOLOGY; PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON TITANIUM, MUNICH, WEST GERMANY, SEPTEMBER 10-14, 1984. VOLUMES 1-4

G. LUETJERING, ED. (Hamburg, Technische Universitaet, West Germany), U. ZWICKER, ED. (Erlangen-Nuernberg, Universitaet, Erlangen, West Germany), and W. BUNK, ED. (DFVLR, Cologne, West Germany) Conference supported by DFG. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985. Vol. 1, 719 p.; vol. 2, 820 p.; vol. 3, 726 p.; vol. 4, 724 p. For individual items see A86-27202 to A86-27421.

Numerous Ti alloy preparation, processing and recycling techniques are discussed. Attention is given to methods of reducing or recycling the amounts of waste chips and/or pollutants which are byproducts of the production and shaping of Ti alloys. The benefits and drawbacks of various techniques for melting Ti ingots and chips are explored, along with the microstructures of hot isostatically pressed materials. Forming techniques such as hot die forming, rolling and extrusion are investigated as to their effects on the microstructures of finished billets, their relative costs, and their capabilities of yielding near-net shape parts. Finally, the potential for using new techniques which require lower heats and thereby reduced costs so that parts can be manufactured from more economical Ti alloys at competitive costs are investigated. M.S.K.

**A86-27202**

### APPLICATIONS OF TITANIUM AND TITANIUM ALLOYS

T. W. FARTHING (IMI Titanium, Ltd., Birmingham, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 39-54.

Areas of applications of Ti alloys are surveyed, together with the prospects of improving the quality of the products. The demand for Ti products will continue to rise due to the favorable properties of Ti in aircraft components, even though the number of aircraft produced may not increase by much. Ti offers high temperature creep resistance, improved performance from rotating parts, and can be shaped using techniques such as superplastic forming and diffusion bonding. New gas turbine engines feature up to 25 percent by weight Ti, mainly in the blades, disks and housing. The same percentage is used in current military aircraft airframes and control surfaces, falling to 7 percent in commercial aircraft. Attempts are being made to increase the percentage of parts by increasing the quality of HIP-manufactured components. In other areas, Ti has proven useful in salt water environments, particularly for deep-sea diving vessels and heat exchangers. Ti alloys have shown no adverse effects when used in prosthetic devices and have shown no adverse effects when used in prosthetic devices and have exhibited favorable properties when combined with other elements in superconductors. M.S.K.

**A86-27207**

### AN EVALUATION OF CENTRIFUGALLY CAST TI-4AL-4MO-2SN-0.5SI (IMI 550) ALLOY

M. W. KEARNS (IMI Titanium, Ltd., Birmingham, England) and C. M. WARD-CLOSE (Royal Aircraft Establishment, Farnborough, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 195-202. Research supported by the Ministry of Defence (Procurement Executive). refs

The results of tests of the room temperature tensile, fracture toughness and plain and notched high cycle fatigue life of centrifugally cast and cast/HIPped IMI 550 Ti alloy are reported. Three specimens, 70, 125 and 180 mm long, were centrifugally cast and subjected to HIP conditions and heat treatment of 1 hr at 900 C, air cooling and aging for 24 hr at 500 C. Other samples were prepared with the same process as Ti-6Al-4V and with varying thickness as would be found in an aerospace component. The mechanically tested parts were examined by radiography and microscopy. The fully aged IMI 550 alloy yielded a 20 percent increase in mechanical properties compared to samples of Ti-6Al-4V. The HIP process eliminated shrinkage porosity by retained the beta acicular features. However, HIPping increased the plain specimen fatigue performance to twice that of comparable wrought alloy materials. M.S.K.

**A86-27209**

### REQUIREMENTS FOR RECYCLING OF VALUABLE CHIPS FROM AND FOR AIRCRAFT MANUFACTURING

J. BERGGREEN (Messerschmitt-Boelkow-Blohm GmbH, Augsburg, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 241-248.

The ratio of scrap chips of Ti to the actual materials used in making stiffened airframes can appraoch 100:1, although chips are valued at only 0.01 the worth of raw material. Neither electrolytic dissolving nor powdering of the chips to obtain useful Ti alloy forms is a cost-effective process. Another significant impediment to recycling the chips is keeping them from being mixed with other materials, such as cigarette ends, glass splinters, other metal scraps, milling coolants, etc., in the shop. A system is described whereby the chips are removed from the workbench by vacuum suction or conveyers and transferred to a storage location. The chips are carried to a recycling plant in sealed containers which are inspected by X ray techniques. Remelted scrap handled to avoid contamination has exhibited mechanical properties and chemical composition equivalent to the original Ti sponge, provided the oxygen content is closely controlled during remelt and sufficient sponge material is added to the melt. M.S.K.

**A86-27224**

**DEVELOPMENT IN PM HHDH-TI6AL4V TECHNOLOGY FOR AIRCRAFT APPLICATION**

R. TANG, T. LAN, and C. LU (Baoji Institute for Nonferrous Metal Research, People's Republic of China) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 443-450. refs

The preliminary results of the development in the High-quality Hydride Dehydriding Process (HHDH) on PM Ti6Al4V alloy for aircraft applications are described in the paper. The powder characteristics and the mechanical properties of HHDH-Ti6Al4V alloy consolidated by HIP are presented. The effects of HIP temperature, powder particle size and its oxygen content on the microstructure and mechanical properties of HHDH-Ti6Al4V alloy are discussed in detail. The experimental result shows that the mechanical properties of the HHDH alloy can be compared with the best properties of HIP'ed centrifugal atomization Ti6Al4V and conventional wrought material reported up to now. Furthermore, the HHDH process has even more advantages and possesses the competition in the cost effectiveness. Therefore, the HHDH process will be a more economical and important approach to manufacture the PM titanium alloy components for aircraft applications. M.S.K.

**A86-27231**

**EFFECT OF PROCESSING AND HEAT TREATMENT ON THE MECHANICAL PROPERTIES OF TI-6AL-2SN-4ZR-6MO ALLOY**

H. YANO, Y. TSTUMORI, T. MATSUMOTO, K. YASUI, and T. NISHIMURA (Kobe Steel, Ltd., Japan) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 507-514.

Experimental trials were run to determine the minimum forging reduction in the alpha-beta field to obtain good ductility for the alloy Ti-6246. Attention was also given to the impacts that solution treatment conditions have on the mechanical properties of the alloy. Various forging reductions up to 80 percent in the alpha-beta field were imposed on alloy bars forged at 900 C. The bars were later tested for the tensile properties. Heat treatment effects were evaluated in terms of the results of tensile, notch test, and creep tests. Tensile strength was not affected by the forging reduction while elongation and areal reduction were both observed with forging reductions of 53-63 percent. The amount of age hardening determined the tensile strength of the end product. A double solution treatment produced enhanced tensile strength and creep resistance. The second treatment caused the material to become at least 10 percent alpha phase. The mechanical properties of all the solution treated die forged specimens satisfied criteria for use as jet engine disks. M.S.K.

**A86-27260**

**PROPERTIES OF DIFFUSION BONDED BUTT JOINTS IN TI-6AL-4V AND TI-4AL-4MO-2SN-0.5SI (IMI 550) ALLOYS**

T. S. BAKER and P. G. PARTRIDGE (Royal Aircraft Establishment, Farnborough, England) IN: Titanium: Science and Technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 861-868. refs

A critical requirement for successful superplastic forming/diffusion bonding of Ti-6Al-4V and IMI550 Ti alloys is an understanding of the factors affecting the mechanical properties of diffusion bonds. Tensile, fatigue and impact strengths are presently determined for butt joints containing various amounts of residual porosity at the interface, following diffusion bonding. The results obtained suggest that, unless impact strength is more sensitive to the presence of very small voids than is the fatigue testing method, toughness is reduced by the presence of an oxygen-rich region near the bond interface. O.C.

**A86-27264**

**FATIGUE-CRACK PROPAGATION THROUGH TITANIUM WELDS**

P. S. PAO, T. C. PENG, and J. E. ONEAL (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 887-894. Research supported by the McDonnell Douglas Independent Research and Development Program. refs

Attention is given to the influence exerted by gas-tungsten arc, electron beam, and laser beam weldment microstructures on the mechanical properties and fatigue crack growth kinetics of the alpha-beta alloy Ti-6Al-4V and the beta alloy Ti-15V-3Cr-3Al-3Sn. Modified wedge-opening-load specimens oriented either longitudinally or transversely were used to determine crack growth kinetics. It is found that the fatigue crack growth rates through the weld zones of both alloys are not significantly affected by the three welding processes, although scatter bands for electron and laser beam welding are narrower than for the gas-tungsten arc process. O.C.

**A86-27274**

**FATIGUE PROPERTIES OF TI-10V-2FE-03AL**

R. S. CAREY (Beckman Instruments, Inc., Palo Alto, CA), R. R. BOYER (Boeing Co., Seattle, WA), and H. W. ROSENBERG (Timet, Pittsburgh, PA) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1261-1267. Research supported by the Boeing Co. and Timet.

The near-beta titanium forging alloy Ti-10V-2Fe-3Al has come to find frequent use in state-of-the-art commercial aircraft in virtue of its outstanding combination of weight reduction-yielding strength and toughness; recent investigations have noted excellent fatigue strength, as well. Attention is presently given to the results of investigations concerning applications where fatigue may be a critical factor: commercial airframes, helicopters, and centrifuges. In each case, Ti-10V-2Fe-3Al appears to outperform the heretofore more prominent Ti-6Al-4V alloy. O.C.

**A86-27275**

**FATIGUE BEHAVIOUR OF TITANIUM MATERIALS IN AIRCRAFT ENGINES**

R. GRAETER and H. HUFF (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1269-1273.

Because the fatigue strength of titanium and its alloys is strongly influenced by such factors as surface finish, structure topology and material microstructure, as well as by fretting, precise definitions of surface and structure are required. An evaluation is presently made of the interrelationships among these factors, with attention to the consequences of microstructure type, the influence of tool-originated flaws on structure surface, and the geometry of loads incurred during operation (in such cases as turbomachine blades) which cause significant fretting. O.C.

**A86-27279**

**EMBRITTLED TRAILING EDGES OF COMPRESSOR BLADES (TITANIUM ALLOY TI6AL-4V AND TI6AL2SN4ZR2MO) OF GAS TURBINE AERO-ENGINES**

J. SPECHT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1301-1306.

The embrittlement recently noted at the trailing edges of aircraft gas turbine compressor blades is due to hydrogen, which is present in the form of titanium hydride; its absorption may be promoted by the rough airfoil surface at the upper half of the trailing edge, which is caused by surface enlargement. Hydrogen absorption is found to occur, not from moisture during operation, but from cleaning baths given in the course of maintenance with a solution of NaOH + $Na_2Cr_2O_7$. The cleaning procedure has accordingly been modified. O.C.

**A86-27370**

**THE FRETTING FATIGUE BEHAVIOUR OF THE TITANIUM ALLOY TI-6AL-4V**

E. BROSZEIT, K. H. KLOOS, and B. SCHWEIGHOEFER (Darmstadt Technische Hochschule, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2171-2178. DFG-supported research.

The phenomenon of fretting can be observed in many cases. It can arise, for instance, at the blade foot of turbine blades. In this case, weld marks can be the consequence of oscillating sliding movements of very small amplitude. In aircraft engines with turbine blades made from titanium alloys, macrocracks can develop as the result of fretting. The considered study is concerned with the fretting fatigue behavior of the material combination Ti-6Al-4V/Ti-6Al-4V, taking into account the feasibility of improvements on the basis of material and surface modifications. It is found that the fretting fatigue properties of the considered material combination can be improved by a number of approaches, giving attention to the combination of high residual compressive stresses with a shear resilient surface. Such a surface can be obtained by selecting a favorable machining process, or by applying soft coatings. G.R.

**A86-27383**

**THE STRAIN CONTROLLED FATIGUE BEHAVIOUR OF A NEAR-ALPHA TITANIUM ALLOY**

M. R. WINSTONE and M. J. WEAVER (Royal Aircraft Establishment, Farnborough, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2275-2280. refs

This paper presents the results of an investigation which has been conducted to assess the strain controlled fatigue behavior of the near-alpha titanium alloy IMI 829 in the temperature range from 20 to 300 C. A zero to maximum strain cycle was employed for all the tests. Attention is given to details regarding the experimental procedure, the results, and aspects of engineering significance. When the near-alpha titanium alloy IMI 829 was fatigue tested under strain control using O-Max triangular waveform (0.0167 Hz), the life to failure for a given inelastic strain range was found to increase slightly with temperature in the range from 20 to 300 C. At 20 C and 80 C, the introduction of a 120 second hold time at maximum strain increases the inelastic strain range for a given cyclic life, whereas at 120 and 300 C, the relationship remains unchanged. G.R.

**A86-27384**

**STUDIES ON CRACK GROWTH RATE OF HIGH TEMPERATURE TITANIUM ALLOYS**

S. FUJISHIRO (USAF, Materials Laboratory, Wright-Patterson AFB, OH) and T. MATSUMOTO (Kobe Steel, Ltd., Japan) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2281-2288. refs

The present study is concerned with the identification of a processing method which provides the lowest crack growth rate for high temperature Ti alloys commonly employed in aircraft engines. Ti-6246, which is utilized in advanced jet engine components, has a very high strength. However, prior studies indicate that this alloy has a much faster fatigue crack growth (FCG) rate than other high-temperature Ti alloys. Investigations were, therefore, conducted with the aim to improve the FCG rate of Ti-6246 by thermomechanical processing, taking into account also Ti-6242S, and Ti-64. At room temperature, Ti-6246, regardless of the type of processing used, was found to have the fastest FCG rate of all alloys studied. G.R.

**A86-27385**

**HIGH TEMPERATURE FATIGUE BEHAVIOR OF IMI 685**

R. MARISSEN, M. PETERS, K. SCHULTE, K.-H. TRAUTMANN, and H. NOWACK (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2289-2296. DFG-supported research. refs

Near-alpha-titanium alloys show a high/specific strength combined with good corrosion resistance, and, when compared to the (alpha+beta)-Ti alloys, superior high temperature properties. For this reason, the considered alloys are widely used as compressor disk material for gas turbine aircraft engines, and information about fatigue crack initiation and crack propagation is important. The present paper is concerned with the crack propagation stage. A description is given of studies performed on the near-alpha Ti alloy IMI 685 (Ti-6Al-5Zr-0.5Mo-0.25Si). It is found that a fine equiaxed and a coarse lamellar microstructure shows considerably lower crack growth rates as compared to a fine equiaxed microstructure for room temperature as well as for 450 C. G.R.

**A86-27388**

**DEVELOPMENTS IN HIGH TEMPERATURE ALLOYS**

P. A. BLENKINSOP (IMI Titanium, Ltd., Birmingham, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2323-2338. refs

The earliest work concerning high temperature alloys was carried out in the U.S. in the early 1950s. The alloys considered included alpha phase alloys, alpha+beta phase alloys, and meta-stable beta phase alloys. It was soon recognized that solid solution strengthening of the alpha phase with additions of Al, Sn, and Zr provided improvements in room and elevated temperature tensile and creep properties. Attention is given to attempts to develop 'super alpha' alloys in the mid to late 1950s, UK alloys in this group, the Ti+beta stabilizing element, Ti+alpha and beta stabilizing elements, advances in the development of creep resistant titanium alloys in the late 1950s, effects of an addition of Zr and Si, major developments related to aircraft engines and the acceptance of titanium alloys in the 1960s, and a major change of alloy philosophy occurring in the UK. Recent developments discussed are related to the importance of fatigue strength, the utilization of the effect of the cooling rate, and new development alloys. New developments are partly concerned with the temperature barrier at 600-650 C. G.R.

**A86-27652#**

### ANALYTICAL AND EXPERIMENTAL STUDIES OF TEXTILE STRUCTURAL COMPOSITES

T.-W. CHOU (Delaware, University, Newark), B. I. SHEHATA (U.S. Army, Ballistic Research Laboratory, Aberdeen Proving Ground, MD), and J.-M. YANG IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 13 p. Army-Navy-supported research. refs

This paper reports the recent research in modeling the thermo-elastic behavior of textile structural composites and the parametric study of composite performance. Firstly, a three-dimensional finite-element analysis has been performed to determine the elastic properties of plain weave fabric composites, which have not been accurately predicted by the previous modeling work. The theoretical and experimental results coincide very well. Secondly, a parametric study has been performed on cross-ply, angle ply, woven fabric and three-dimensional braided composites. The variation of thermo-elastic properties of these composites with fiber and matrix properties, fiber orientation, and weaving and braiding parameters have been identified. The unique performance of textile structural composites has been demonstrated. Author

**A86-27691**

### LIFE PREDICTION FOR AROMATIC POLYAMIDE REINFORCEMENTS

A. HOWARD and N. J. PARRATT (Royal Armament Research and Development Establishment, Waltham Abbey, England) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 277-292. refs

Mechanical tests have been carried out on Kevlar 49 yarn of 1420 denier with a view to estimating the useful life of this aromatic polyamide fiber used in aircraft and missile composite structures. It is shown that the tensile creep observed in Kevlar 49 yarn under dry conditions is reversible and unrelated to the loss of strength with time. There is instead a consolidation of the normal fiber under stress, reflected in a permanent increase in elastic modulus. From stress-rupture data at 150, 110, and 65 C, the most probable yarn lifetimes are predicted at temperatures between 25 and 200 C and stress levels between 10 and 70 percent of the ultimate strength. V.L.

**A86-27702**

### S-2 GLASS FIBER - ITS ROLE IN MILITARY APPLICATIONS

S. J. WALLING (Owens-Corning Fiberglas Corp., Advanced Composites Marketing Section, Toledo, OH) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 443-456.

An introduction to S-2 glass fiber products, the fiber and composite properties, and the benefits of the products is presented. Comparative data for S-2 glass and E-glass are given, including physical properties, thermal properties, electrical properties, corrosion resistance, tensile and shear strength. The strength properties of laminates of these glasses are shown. Current applications of S-2 fibers are discussed, stressing lightweight composites in military vehicle structures and armor. C.D.

**A86-27730*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### AEROSPACE APPLICATIONS OF PMR POLYIMIDE COMPOSITES

T. T. SERAFINI (NASA, Lewis Research Center, Cleveland, OH) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1007-1023. refs

The current status of the novel class of processable, addition-type polyimides known as PMR (for in situ polymerization of monomer reactants) polyimides, developed by NASA at the Lewis Research Center, is reviewed. Highlights of PMR technology studies conducted at NASA Lewis are presented. Several examples of industrial applications of PMR-15 polyimide composites to aerospace structural components are examined. C.D.

**A86-27754**

### DIFFUSION OF WATER IN CARBON EPOXY COMPOSITES

M. A. GRAYSON and C. J. WOLF (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1463-1473. refs

An innovative method, Precision Abrasion Mass Spectrometry (PAMS), has been used to investigate the diffusion of water in a high performance neat epoxy resin, a unidirectional carbon epoxy composite, and a cross-ply carbon epoxy composite. Test coupons were immersed in water at 50, 65, and 80 C for time intervals up to 5000 h. PAMS and gravimetric data were used to investigate diffusion processes in these materials. Two diffusion processes are observed in the resin, one fast and presumably Fickian, the other a factor of 30 slower and non-Fickian. The early stages of diffusion in the resin and the composites are essentialy the same and have an activation energy of 49 kJ/mol. The diffusion coefficient in the unidirectional composite, calculated on the basis of the fibers occupying a finite volume, is in good agreement with the measured values. Author

**A86-27759**

### NEW ARAMID DEVELOPMENTS FOR AEROSPACE/AIRCRAFT APPLICATIONS

J. J. PIGLIACAMPI and G. E. ZAHR (Du Pont de Nemours and Co., Wilmington, DE) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1545-1556.

Near-term aramid fiber research and development is discussed, with emphasis on its utility in aircraft/aerospace applications. The tensile strength and adhesion characteristics of new aramid fibers are given and their practical significance is addressed. New products with aramid fibers are described, including improved roving for pressure vessels, low denier Kevlar 49, short fibers, pulp-reinforced elastomers, and low-density spunlaced aramid sheet products. New applications of aramid fibers in the areas of phenolic systems for aircraft interiors, radomes, and supertough wrapped rods are discussed. C.D.

**A86-27765**

### SOME RECENT RESEARCH AND DEVELOPMENT OF COMPOSITES IN JAPAN

T. HAYASHI (Japan Plastics Inspection Association, Tokyo) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1641-1654. refs

Japan's project on advanced composite materials is discussed. The aim of the project is to create fiber reinforced plastic (FRP) and fiber reinforced metal (FRM) composites applicable to aerospace structures and jet engines. The development of high performance FRPs and FRMs, and of fabrication techniques for FRPs and FRMs are described. New procedures for design technology and quality evaluation technology are examined. I.F.

**A86-28096**

**SYNTHETIC LUBRICANTS AND WORKING FLUIDS; INTERNATIONAL COLLOQUIUM, 4TH, ESSLINGEN, WEST GERMANY, JANUARY 10-12, 1984, REPORTS [SYNTHETISCHE SCHMIERSTOFFE UND ARBEITSFLUESSIGKEITEN; INTERNATIONALES KOLLOQUIUM, 4TH, ESSLINGEN, WEST GERMANY, JANUARY 10-12, 1984, VORTRAEGE]**

W. J. BARTZ, ED. Esslingen, West Germany, Technische Akademie Esslingen, 1984, 640 p. In German and English. No individual items are abstracted in this volume.

Important subjects relevant to synthetic fluids and their application as lubricants and operational fluids are discussed. The topics covered include: ester base stocks, analysis of ester constituents in synthetic and semisynthetic oils, brake fluids, lubrication of plastics by perfluoropolyether fluids, frictional behavior of experimental synthetic and semisynthetic gear oils, potential performance of synthetic fluids for automotive gear oil applications, process variables in the manufacture of polyalphaolefins, synthetic lubricants for turbocharged passenger cars, gas engine lubricants, and nonflammable hydraulic system development for aerospace. Also discussed are: synthesis and properties of adamantine synthetic lubricants, lubrication and cooling in electricity generating plants, industrial applications of synthetic lubricants, waste treatability of aqueous-based synthetic metalworking fluids, characteristics of synthetic lubricating greases, shell fire-resistant grease, synthetic protective lubricants, experience with lead-free gear oils, properties and applications of perfluoropolyether lubricants, spreading of perfluorinated fluids on metal surfaces, and oxidation and inhibition of pentaerythritol esters. C.D.

**N86-20499*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE 1-(DIORGANOOXPHOSPHONYL)METHYL-2, 4- AND -2, 6-DINITRO AND DIAMINO BENZENES AND THEIR DERIVATIVES Patent Application**

J. A. MIKROYANNIDIS and D. A. KOURTIDES, inventors (to NASA) 16 Aug. 1984 19 p
(NASA-CASE-ARC-11425-2; NAS 1.71:ARC-11425-2;
US-PATENT-APPL-SN-641152) Avail: NTIS HC A02/MF A01
CSCL 07C

The 1-Diorganooxyphosphonyl)methyl] -2,4- and -2,6-dinitro- and diamino benzenes are prepared by nitrating an (organophosphonyl)methyl benezene to produce the dinitro compounds which are then reduced to the diamino compounds. The organo groups (alkyl, haloalkyl, aryl) on the phosphorus may be removed to give the free acids (HO)2P(=O)-. The diamino compounds may be polymerized with dianhydrides or diacyl halides to produce fire and flame resistant polymers which are useful in the manufacture of aircraft structures. NASA

**N86-20508*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STRENGTH OF GRAPHITE/EPOXY BOLTED WING-SKIN SPLICE SPECIMENS SUBJECTED TO OUTDOOR EXPOSURE UNDER CONSTANT LOAD AND YEARLY FATIGUE LOADING**

G. R. WICHOREK and J. H. CREWS, JR. 1986 35 p refs
(NASA-TP-2542; L-16065; NAS 1.60:2542) Avail: NTIS HC
A03/MF A01 CSCL 11D

The results of an experimental study to provide long-term durability data on detailed full-scale graphite/epoxy wing-skin joint designs under environmental exposure and cyclic loading associated with commercial transport aircraft are reported. The specimens consisted of a single-row bolt configuration fabricated from T300/5208 and a double-row bolt configuration fabricated from T300/5209. The unpainted specimens were exposed to the outdoor environment under a sustained tensile load, and at yearly intervals, they were subjected to fatigue loading. Experimental results showed a slight reduction in residual tensile strength for both graphite/epoxy joints under the exposure times and fatigue loadings reported. A 7.5-percent decrease in residual strength was observed for the T300/5208 single-row joint after 5 years exposure and two lifetimes of fatigue loading. A 5.3-percent decrease in residual strength was observed for the T300/5209 double-row joint after 7 years exposure and 2.8 lifetimes of fatigue loading. The 5208 epoxy material was more susceptible to degradation by ultraviolet radiation than the 5209 epoxy material. Author

**N86-20522#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**FUEL PROPERTY EFFECTS ON COMBUSTION Final Report, Sep. 1984 - Apr. 1985**

C. A. OBRINGER Oct. 1985 20 p
(Contract AF PROJ. 304-8)
(AD-A162451; AFWAL-TR-85-2051) Avail: NTIS HC A02/MF
A01 CSCL 21D

This report deals with fuel property effects on gas turbine engine combustors. In order to increase jet fuel availability and decrease cost, the Air Force is investigating alternate feedstocks such as tar sands, shale oils, heavy oils, and coal derived fuels. As these lower quality feedstocks begin to play a major role as sources of military jet fuels, it becomes increasingly important to be able to evaluate the effects of these fuels on engine life and performance. These effects have usually been measured using expensive and time-consuming engine tests. Of major concern in each of these programs was the effects of fuel properties and composition on soot formation, and the effects of soot on engine performance and durability. Being able to predict the change in soot formation due to changing fuel properties would be an invaluable tool in future research and development efforts to eliminate soot formation and its deleterious effects on engines. The reduction in exhaust plume, through reduced soot formation, reduces a vehicle's visibility for tracking and targeting purposes, thus increasing its survivability. It was concluded that smoke and combustion linear radiative heating correlate well with hydrogen content. That hydrogen content is as effective as any parameter at predicting soot formation; and the questioning of the validity of the data, and the need for more and better data. GRA

**N86-20560*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**COPOLYMERS OF VINYL STYRYLPYRIDINES OR VINYL STILBAZOLES WITH BISMALEIMIDE Patent**

J. A. PARKER, A. H. HEIMBUCH, M. T. S. HSU, and T. S. CHEN, inventors (to NASA) 2 Jul. 1985 11 p Filed 18 Nov. 1983
(NASA-CASE-ARC-11429-1-CU; US-PATENT-4,526,925;
US-PATENT-APPL-SN-553339; US-PATENT-CLASS-524-548;
US-PATENT-CLASS-525-186; US-PATENT-CLASS-526-262;
US-PATENT-526-265) Avail: US Patent and Trademark Office
CSCL 11B

Vinyl pyridines including vinyl stilbazole materials and vinyl styrylpyridine oligomer materials are disclosed. These vinylpyridines form copolymers with bismaleimides which copolymers have good fire retardancy and decreased brittleness. The cure temperatures of the copolymers are substantially below the cure temperatures of the bismaleimides alone. Reinforced composites made from the cured copolymers are disclosed as well.

Official Gazette of the U.S. Patent and Trademark Office.

**N86-20569#** Department of the Navy, Washington, D. C.

**CONDUCTIVE HETEROCYCLIC LADDER POLYMERS Patent Application**

O. K. KIM, inventor (to Navy) 30 May 1985 10 p
(AD-D011915; US-PATENT-APPL-SN-739354) Avail: NTIS HC
A02/MF A01 CSCL 07C

The present invention pertains generally to electroactive materials and in particular to electroactive organic ladder polymers. The electrical properties of organic polymers have attracted a great deal of attention from the scientific and industrial communities. Conductive polymers would be useful for the production of light weight batteries for electric vehicles and for use in place of metallic conductors aboard aircraft, where weight is and important consideration. They may also prove useful where corrossion resistance is required. It is one object of this invention to obtain and organic ladder polymer with high electrical conductivity. It is a further object of this invention to obtain a conductive ladder polymer that is stable against both thermal and chemical degradation.

Phenothiazine Ladder Polymer, PTL (or di-chloro-PTL) was prepared by polycondensation of 2,5-diamino-1, 4-benzenedithiol with 2,5 dichloro (or 2,3,5,5-tetrachloro)-p-benzoquinone in polyphosphoric acid at 250 C. Phenoxazine Ladder Polymer, POL, was prepared from 2,5-dichloro-p-phylendiamine and 2,5-dihydroxy-p-benezoquinone under the same conditions as used for PTL synthesis. Di-chloro-POL and other derivatives can be made under a similar condition. These polymers conduct electricity. GRA

**N86-20580#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**PRODUCIBILITY AND COST STUDIES OF AVIATION KEROSENE**

C. C. ROSEN, III, ed. Jul. 1985 51 p refs

(AGARD-AR-227; ISBN-92-835-1504-8) Avail: NTIS HC A04/MF A01

A computer analysis conducted by Exxon Research and Engineering Company and NASA used standard refinery planning methods to determine the optimum processing path within model refineries to achieve minimum cost for various product outputs. Crude feedstock types were combined and refinery configurations selected to create regional calculation models. Principal objectives were: to determine the effect of jet fuel quality variations on the maximum yield of jet fuel; to determine the effect of jet fuel quality variations on refining costs for regional models based on future supply and demand; and to determine, for the United States Air Force, the effect of changing from wide cut (naptha) to kerosene jet fuels on refining cost and production yield in the United States and Europe. B.G.

**N86-21615#** B and M Technological Services, Inc., Cambridge, Mass.

**STATE-OF-THE-ART REVIEW ON COMPOSITE MATERIAL FATIGUE/DAMAGE TOLERANCE Final Report, Jul. - Nov. 1984**

R. L. AMORY and D. S. WANG Dec. 1985 81 p refs

(Contract DTFA03-84-C-00052)

(FAA/CT-85/7; FAA-84-03-F) Avail: NTIS HC A05/MF A01

A state of the art review on composite material fatigue/damage tolerance was conducted to investigate the literature for fatigue life prediction methodologies including stress based methodologies, strength degradation models, and damage growth models. A critical review was made of each methodology and its commensurate basic equations of importance. Experimental data were reviewed and the behavior of specimens was correlated with that of civil aircraft components. Six recognized methods for the non-destructive testing of fibrous composite materials were examined and the most effective methods identified. Author

**N86-21662#** Fairchild Republic Co., Farmingdale, N.Y.

**STRUCTURAL EVALUATION OF SUPERPLASTIC ALUMINUM. PART 1. MECHANICAL, CORROSION, METALLURGICAL DATA Final Report, Jun. 1983 - Mar. 1985**

H. C. LIPSIUS, J. STOCK, and A. SHAMES Aug. 1985 120 p

(Contract F33615-83-C-3208)

(AD-A161366; AFWAL-TR-85-3050-PT-1) Avail: NTIS HC A06/MF A01 CSCL 11F

The mechanical, corrosion, metallurgical and secondary fabricability properties of the superplasticity formable Supral alloy were evaluated to assess the amenability of these alloys to standard aircraft practices. Fracture and fatigue properties were evaluated through extensive testing of superplasticity formed parts and discs. The mechanical property test results meet Alcan/Superform claims provided that the microaviation is restricted to less than three percent of the volume. Research findings show that Supral 100, 150, and 220 are alloys suitable for aircraft use. Testing of shop manufacturing practices and welding techniques indicate that the Supral alloys are comparable to standard U.S. aluminum alloys. GRA

**N86-21686*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AMINOPHENOXYCYCLOTRIPHOSPHAZENE CURED EPOXY RESINS AND THE COMPOSITES, LAMINATES AND STRUCTURES THEREOF Patent Application**

D. KUMAR (NRC-NAS), G. M. FOHLEN, and J. A. PARKER, inventors (to NASA) 21 Nov. 1985 22 p

(NASA-CASE-ARC-11548-1; NAS 1.71:ARC-11548-1; US-PATENT-APPL-SN-806572) Avail: NTIS HC A02/MF A01 CSCL 11B

Aminophenoxycyclotriphosphazenes such as hexakis(4-aminophenoxy)cyclotriphosphazene and tris(4-aminophenoxy)-tris phenoxycyclotriphosphazene are used as curing agents for epoxy resins. These 1,2-epoxy resins are selected from di- or polyepoxide containing organic moieties of the formula (CH2-CHO-CH2)m-W-R-W-(CH2CH-CH2O)m where R is diphenyldimethylmethane, diphenylmethane, bis(dibromophenyl)dimethylmethane. W is a nitrogen or oxygen atom; and m is 1 when W is oxygen and 2 when W is nitrogen. The resins are cured thermally in stages at between about 110 to 135 C for between about 1 and 10 min, then at between about 175 to 185 C for between about 0.5 to 10 hr and post-cured at between about 215 and 235 C for between about 0.1 and 2 hr. These resins are useful for making fire resistant elevated temperature stable composites, laminates (e.g., graphite fiber or fiberglass), molded parts, and adhesives and structures, usually for aircraft secondary structures and for spacecraft construction. NASA

**N86-21704*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.

**DEVELOPMENT OF LC-13C NMR Final Annual Report, 10 Jan. 1984 - 9 Jan. 1985**

H. C. DORN, J. S. WANG, and T. E. GLASS 17 Mar. 1986 20 p refs

(Contract NAG3-517)

(NASA-CR-176656; NAS 1.26:176656) Avail: NTIS HC A02/MF A01 CSCL 21D

This study involves the development of C-13 nuclear resonance as an on-line detector for liquid chromatography (LC-C-13 NMR) for the chemical characterization of aviation fuels. The initial focus of this study was the development of a high sensitivity flow C-13 NMR probe. Since C-13 NMR sensitivity is of paramount concern, considerable effort during the first year was directed at new NMR probe designs. In particular, various toroid coil designs were examined. In addition, corresponding shim coils for correcting the main magnetic field (B sub 0) homogeneity were examined. Based on these initial probe design studies, an LC-C-13 NMR probe was built and flow C-13 NMR data was obtained for a limited number of samples. Author

**N86-21707#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**F100 FUEL SAMPLING ANALYSIS Final Technical Report, May 1983 - Apr. 1984**

L. Q. MAURICE Sep. 1985 136 p

(Contract AF PROJ. 3048)

(AD-A161667; AFWAL-TR-85-2045) Avail: NTIS HC A07/MF A01 CSCL 21D

Fuel pump cavitation problems experienced with the F100 engine used in the F-15/F-16 aircraft have led to an extensive fuel analysis program to identify fuel properties that might be contributing to fuel pump failures. This report analyzes the chemical and physical properties of twenty-one JP-4 fuel samples obtained from United States Air Force Bases. The fuels analyzed met specifications in all but a few isolated cases, and had no unusual properties. If the fuel used is causing fuel pump failure, it must be the result of a fuel property not being measured. The fuels are as good or better than the specification prescribes. It is concluded that the F100 fuel pump cavitation problems are most likely associated with the mechanical complexity built into the design, rather than the result of the fuel used. GRA

## 12

## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-26336**

**THE THERMO-MECHANICAL PROCESSING DURING CLOSED DIE FORGING - A METHOD OF IMPROVING AERONAUTICAL MATERIALS [LE TRAITEMENT THERMOMECANIQUE PAR MATRICAGE - FACTEUR D'AUGMENTATION DES PERFORMANCES DES MATERIAUX AERONAUTIQUES]**

F. CHEVET and A. GAVART (Compagnie Francaise de Forges et Fonderies, Paris-la-Defense, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Materiaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 611-617. In English and French.

In closed die forging, the general aim of thermomechanical processing, which is to improve mechanical properties through the control of structure by hot working, is extended to the control of local strains; difficulties arise, however, in that closed die hot forming does not yield homogeneous strain throughout the volume of the metal being worked. The development of simulation techniques that can 'visioplastically' determine local strain at every location has accordingly been undertaken. These techniques have yielded the ability to forge aircraft gas turbine elements requiring precise structural contour control, such as superalloy gas turbine disks. These techniques may also be applied to titanium, steel, etc. O.C.

**A86-26544**

**RELIABLE NONDESTRUCTIVE TESTING - THE KEY TO USING WELDMENTS IN CRITICAL FIGHTER AIRCRAFT STRUCTURE**

R. J. LORD and P. J. RAMSEY (McDonnell Aircraft Co., St. Louis, MO) Materials Evaluation (ISSN 0025-5327), vol. 44, Feb. 1986, p. 209-214, 208. refs

A nondestructive testing (NDT) procedure was developed for the purpose of controlling the weld quality of electron beam welds in critical fighter aircraft structures subjected to complex load patterns. The weldment is inspected using liquid penetrant, ultrasonic, and X-ray techniques designed specifically for the part configuration. The primary considerations of the NDT are: (1) the importance of X-ray beam alignment for detection of lack of fusion, (2) the effect of surface finish on ultrasonic inspection, and (3) the importance of pickling prior to penetrant inspection. An X-ray technique for confirming proper alloy usage was developed, together with a unique X-ray beam alignment indicator and a special sound beam reflection mirror to facilitate the X-ray and ultrasonic inspections. I.S.

**A86-26682*** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EFFICIENT IDENTIFICATION OF CRITICAL STRESSES IN STRUCTURES SUBJECT TO DYNAMIC LOADS**

R. T. HAFTKA, L. T. WATSON (Virginia Polytechnic Institute and State University, Blacksburg), and R. V. GRANDHI Computers and Structures (ISSN 0045-7949), vol. 22, no. 3, 1986, p. 373-386. refs

(Contract NAG1-224; NSF MCS-82-07217)

Optimum structural design problems generally employ constraints which are parametric in terms of space and time variables. A parametric constraint may be replaced by equivalent critical point constraints at its local minima for optimization applications. In complex structures, accurate identification of such critical points is computationally expensive due to the cost of finite element analyses. Three techniques are described for efficiently and accurately identifying critical points for space- and time-dependent parametric constraints. An adaptive search technique and a spline interpolation technique are developed for exactly known response. A least squares spline approximation is suggested for noisy behavior. A helicopter tail-boom structure subjected to transient loading is used as an example to demonstrate the techniques described. All three techniques are shown to be computationally efficient for critical point identification and the least squares approximation also removes noise from the data. The case of multiple constraints per element is shown to be particularly suited to the use of spline techniques. Author

**A86-26717**

**TITANIUM NEAR NET SHAPE COMPONENTS FOR DEMANDING AIRFRAME APPLICATIONS**

R. H. WITT and A. L. FERRERI (Grumman Aerospace Corp., Bethpage, NY) SAMPE Journal (ISSN 0091-1062), vol. 22, Jan.-Feb. 1986, p. 13-18. refs

This paper deals with the viability of Hot Isostatic Pressing (HIP) Near Net Shape (NNS) titanium parts in competition with forged or cast components. The paper summarizes NNS and advanced alloy capability and experience for each process, and includes economic assessments for specific parts varying in size and complexity. Overall results show that HIP offers greatest near-term potential for producing the complex parts considered in this study. Author

**A86-26876**

**COMBINED EXPERIMENTAL/ANALYTICAL MODELING OF DYNAMIC STRUCTURAL SYSTEMS; PROCEEDINGS OF THE JOINT MECHANICS CONFERENCE, ALBUQUERQUE, NM, JUNE 24-26, 1985**

D. R. MARTINEZ, ED. and A. K. MILLER, ED. (Sandia National Laboratories, Albuquerque, NM) Conference sponsored by ASCE and ASME. New York, American Society of Mechanical Engineers , 1985, 235 p. For individual items see A86-26877 to A86-26885.

It is pointed out that modern structural analysis involves the use of both analytical and experimental techniques. The presented papers have the objective to report the state-of-the-art in combined experimental/analytical modeling, including the substructure synthesis techniques and experimental procedures required to apply these techniques in practical applications. An overview of analytical synthesis techniques is provided, taking into account a review of the time-domain and frequency-domain component mode synthesis method. In connection with an overview of modal testing and measurement, modal test requirements for coupled structure analysis using experimentally-derived component models are examined along with excitation, measurement, and analysis methods for model testing. Hybrid experimental/analytical dynamic models of aerospace structures are considered, and structural analysis model validation using modal test data is discussed. A description of case histories and applications is also given. G.R.

**A86-26878#**

**MODAL TEST REQUIREMENTS FOR COUPLED STRUCTURE ANALYSIS USING EXPERIMENTALLY-DERIVED COMPONENT MODELS**

D. J. EWINS (Imperial College of Science and Technology, London, England) IN: Combined experimental/analytical modeling of dynamic structural systems; Proceedings of the Joint Mechanics Conference, Albuquerque, NM, June 24-26, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 31-47. refs

A review is made of some of the methods available for making vibration analyses of complex structures where one or more of the component substructures is modelled from experimental, rather than theoretical, data. These methods are discussed with particular reference to the implications for the test procedures which must be used and attention is focussed on the methods of analysis which are based on response properties. A number of practical problems encountered in typical applications are considered and recommendations made to aid successful implementation of the method. Author

**A86-26803#**

### EXPERIMENTAL SYSTEM IDENTIFICATION FOR EXPERIMENTAL/ANALYTICAL CORRELATION AND MODELLING

N. NIEDBAL (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: Combined experimental/analytical modeling of dynamic structural systems; Proceedings of the Joint Mechanics Conference, Albuquerque, NM, June 24-26, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 195-204. refs

The dynamic qualification of spacecraft structures is considered, taking into account the use of modal survey tests to verify normal mode parameters. A survey is conducted of the state of the art of the classical sine-dwell methods and of some experimental modal analysis methods. The advantage of the new methods is that appropriated exciter forces, in the sense of the sine-dwell method are unnecessary. It is pointed out that in Europe the classical sine-dwell method is preferred to measure the normal mode parameters of the undamped structure for correlation and modelling of experimental and analytical results. Because of its superior flexibility, the model survey test concept is expected to attract increasing interest for purposes of dynamic qualification of future spacecraft structures. G.R.

**A86-26937#**

### RELIABILITY AND FAILURE PREVENTION THROUGH ESA IN THE 80'S AND BEYOND

S. R. KATZ (Measurements Group, Inc., Raleigh, NC) IN: Failure prevention and reliability - 1985; Proceedings of the Conference, Cincinnati, OH, September 10-13, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 123-126.

Experimental stress analysis (ESA) involves the measurement of strains due to the stresses to which a structure or element is subjected, and is applied where there is a risk of structural failure in service. Practical ESA techniques fall into the two broad categories of electronic and optical methods. Strain gage technology, which exemplifies the former category, has been extensively used in the aircraft industry to record the behavior of structural elements under stress. Optical ESA methods include photoelastic coatings and models that operate on the basis of patterns generated by polarized light. O.C.

**A86-27076**

### ENERGY DISSIPATION CONNECTED WITH VIBRATIONS OF MECHANICAL SYSTEMS [RASSEIANIE ENERGII PRI KOLEBANIIAKH MEKHANICHESKIKH SISTEM]

G. S. PISARENKO, ED. Kiev, Izdatel'stvo Naukova Dumka, 1985, 312 p. In Russian. For individual items see A86-27077 to A86-27086.

Results of analytical and experimental studies of the vibrations of various elastic systems under both steady-state and transient conditions are presented, with particular attention given to the effect of energy dissipation. Topics discussed include dissipative properties of cyclically deformed materials, vibrations of machine parts and components, and aerodynamic damping of the vibrations of various mechanical systems. In particular, papers are presented on the nonlinear vibrations of rectangular plates with allowance for energy dissipation; vibrations of shells of imperfectly elastic materials with allowance for geometrical nonlinearity; mathematical models for studying aircraft vibrations with allowance for structural hysteresis; and the effect of a periodic aerodynamic load on the dynamic stress level of the rotor blades of a turbomachine. V.L.

**A86-27126**

### INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY, WAKEFIELD, MA, AUGUST 20-22, 1985, RECORD

Symposium sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1985, 651 p. For individual items see A86-27127 to A86-27157

Various papers on electromagnetic compatibility are presented. The general topics addressed include: EMI transient/impulsive disturbances, electromagnetic shielding, antennas and propagation, measurement technology, anechoic chamber/open site measurements, communications systems, electrostatic discahrge, cables/transmission lines. Also considered are: elecromagnetic environments, antennas, electromagnetic pulse, nonlinear effect, computer/data transmission systems, EMI standards and requirements, enclosures/TEM cells, systems EMC, and test site measurements. C.D.

**A86-27146**

### THE PARALLEL-PLATE AND RHOMBIC EMP SIMULATORS - A SUMMARIZING REVIEW

R. W. P. KING (Harvard University, Cambridge, MA) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 381-384. refs

Tests of the vulnerablity of aircraft and missiles to electromagnetic pulses (EMP) similar to those emanating from a nuclear explosion in the atmosphere are being conducted with the aid of large parallel-plate structures with tapered input and output ends. Thms paper provides a final report of research conducted regarding the employed EMP simulators. The induced surface currents on obstacles are considered along with CW operation of the metal-plate simulator, CW operation of a rhombic simulator, the rhombic simulator under pulse excitation, an experimental study of the metal-plate simulator, supplementary studies, and aspects of simulator-obstacle interaction. G.R.

**A86-27151**

### METHODOLOGY FOR DETERMINATION OF CIRCUIT SAFETY MARGINS FOR MIL-E-6051 EMC SYSTEM TEST

G. LEE and S. D. ELLERSICK (Boeing Military Airplane Co., Seattle, WA) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 502-510. refs

(Contract F33657-81-C-0212)

The MIL-E-6051 electromagnetic compatibility (EMC) system test is concerned with the establishment of safety margins for avionics mission critical circuits. The safety margin (SM) of a circuit is the comparison of the circuit thereshold to the electromagnetic (EM) energy coupled into that circuit. In the case of the B-1B Avionics system certain difficulties were related to the complexity of the system with over 100 subsystem elements called line replaceable units (LRUs). A description is provided of the approaches taken and the analyses performed in selection of B-1B Avionics mission critical circuits to be sensitized or instrumented for test. Attention is given to aspects of methodology, mission critical LRU identification, interface circuit identification, circuit analysis, and wire-to-wire coupling analysis. G.R.

**A86-27157**

### AN OVERVIEW OF THE INTRASYSTEM EMC ANALYSIS PROGRAM WITH GRAPHICS

G. L. BROCK, T. L. BEDFORD, and G. M. GRANGE (Kaman Sciences Corp., Colorado Springs, CO) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 585-592.

The Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP) represents a computer program which was designed to perform EMC analyses of ground, aircraft, spacecraft, and missile systems. A number of improvements for IEMCAP are discussed. The resulting analysis tool with improved capabilities is called the Intrasystem Electromagnetic Compatibility Analysis Program with Graphics (IEMCAP-G). It is pointed out that the improvements help the EMC engineer in evaluating a system for compatibility. Thus, matrices, antenna plots, and line graphs make it possible to tell at a glance the severity of the potential EMI problems. Attention is given to an IEMCAP overview, available options for positive electromagnetive interference (EMI) point margins, detailed interference matrices, the extraction of data, geometry graphics, antenna position graphics, antenna gain patterns, line plots, and an analysis culling technique. G.R.

**A86-27203**

### ENGINEER'S GUIDE TO TITANIUM CASTINGS

R.H. COLLEY IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 151-156.

The main features of the Engineer's Guide to Titanium Castings are summarized. The Guide was developed to supply the essential data for cost-effective designs with Ti alloys. The Guide delineates the special properties of molten Ti in casting processes, particularly the high reactivity of Ti with other elements. Centrifuged molds and investment shell molds and their applications are described, along with the criteria which should be considered when judging whether or not to go to a cast Ti part instead of a wrought part. Design principles to avoid porosity, tooling complexity and shrinkage cavities are reviewed. Minimal stress values are provided for cast Ti alloys (Ti-6Al-4V), and factors to assess when comparing the costs of Ti alloys, which have long lifetimes, with other materials are discussed. M.S.K.

**A86-27204**

### TITANIIUM INVESTMENT CASTING - PRODUCTION, PROPERTIES AND APPLICATIONS

CH. LIESNER (Titan-Aluminum-Feinguss GmbH, Bestwig, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 157-162. refs

Ti alloy casting techniques, repair welding of castings, and areas of applications are discussed. Investment casting by the lost wax method represents a cost savings compared to machining. Ti alloys are preferred for highly stressed aircraft parts, impellers and medical implants. Melting is performed in one of two ways for casting: in electron beam furnaces or in a vacuum arc furnace with a consumable electrode. The latter method offers superior heat distribution and less evaporative loss of alloy elements. Casts are lined with resin-bound graphite, thermodynamic high solid oxides/oxide binders such as ThO2, Y2O3 or CaO, or high melting metals/oxide binders to prevent the intrusion of liner material into the surface of the cast part. Gas holes are prevented by centrifuging the cast with the melt in it. Weld repairs to fractured parts have exhibited mechanical properties similar to the parent material. Cast Ti alloy parts find their greatest applications where a high mechanical strength/specific gravity ratio or a high solidity/low specific gravity ratio is required. Author

**A86-27211**

### RECYCLING OF TITANIUM SCRAP FOR THE PRODUCTION OF HIGH-DUTY AEROSPACE COMPONENTS

H. JAEGER, J. MAYERHOFER, R. TARMANN, J. NEUHOLD, and J. FLADISCHER (Vereinigte Edelstahlwerke AGA, Kapfenberg, Austria) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 257-264. refs

The production of Ti for aerospace applications can consume up to 50 MWh for a ton of Ti ingot, while machining practices can leave up to 90 percent of the original metal as scrap. Recyling reduces the costs of Ti feedstock, and accounts for 30 percent of all Ti used in the U.S. The non-consumable arc furnace (NAF) offers several advantages for recycling operations when compared with the consumable melting furnace (CMF). The benefits include ingots that are 100 percent scrap, control of the loss of alloying trace elements, tailored heating of the melt and no combustibles in the furnace. NAF plants are more expensive than CMF operations, and feature either a skull melting procedure or use of a ceramic-lined crucible. Both methods require a power input of 4.4 MW for a melting rate of 500-600 kg/hr at pressures of 50-100 Pa. The scrap is cut up, pickled and sandblasted, then inspected visually to remove casting, instead of milling or machining, of high performance Ti alloy components of jet aircraft is being developed as an acceptable forming technique which has a significantly lower scrap generation rate. M.S.K.

**A86-27227**

### TEN YEARS OF FRONT-FAN BLADE FORGING

O. VOIGTLAENDER and G. GUENTHER (Thyssen Schmiedetechnik, Remscheid, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 477-481. refs

The drop forge processes employed to shape the front turbofan blades for the RB 211-554 engine are described. About 70,000 of the blades have been delivered since the beginning of the 1970s, each designed to withstand a tangential speed of Mach 1.4 and 780 KN force at the root. The blades were designed using CAD techniques which helped define a die shape that accounted for heat shrinkage, the distribution of contact stresses at the die interface, the elastic contact strains of the die and the mass distributions for preform, intermediate and finish forged shapes. Drop forging is used to alter a rod of machined material into the blade shape after successive twisting and coining operations to produce the desired shape. The transformation stages are balanced to ensure a smooth grain flow along the blade contour. M.S.K.

**A86-27247**

### ISOTHERMAL FORGING SYSTEM FOR THE PRODUCTION OF LARGE ROTATING COMPONENTS FROM TITANIUM ALLOYS OR SUPERALLOYS

F. HUGO (Leybold-Heraeus Technologies, Inc., Enfield, CT), A. HENN, R. DEBES, D. SCHWARZ, F. ANDERLE (Leybold-Heraeus GmbH, Hanau, West Germany) et al. IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 741-744.

**A86-27272**

### PRODUCIBILITY OF AIRCRAFT STRUCTURAL PARTS BY SUPERPLASTIC FORMING AND DIFFUSION BONDING

R. HOLBEIN and K.-F. SAHM (Dornier GmbH, Friedrichshafen, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1237-1244. refs

Weight and cost reduction assessments are made for a variety of aircraft structural components fabricated by superplastic forming/diffusion bonding (SPF/DB) of Ti alloys, with attention to component development management on the basis of experimental efforts. Two-, three-, and four- sheet (as well as single-sheet) basic structural forms from which aircraft structural elements can be compounded by SPF/DB are discussed, and fin, engine mount and fire wall structures produced by these means are evaluated. O.C.

**A86-27278**

### EB REPAIR WELDING OF A CRITICAL AIRCRAFTPART MADE FROM THE NONWELDABLE TITANIUM ALLOY 3.7184.7 (TI-AL4-MO4-SN2-SI)

G. NEYE and A. KOLLEY (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1291-1298. refs

Attention is given to the electron beam welding-based repair method used for the Ti alloy flap carriage torsion cell of the A300 airliner, which cost only about 28 percent as much as the fabrication of a new component. Electron beam welding yielded no distortion due to thermal loads, and no embrittlement of the weld area due to gas absorption. It is noted that such welding-based repair operations make possible the restoration of defective or damaged items for unrestricted subsequent use, at economical cost. O.C.

**A86-27371**

**FRETTING FATIGUE TESTING WITH A FRETTING BRIDGE EQUIPMENT STRESS ANALYSIS, AMPLITUDES OF SLIP, RELIABILITY**

E. BROSZEIT, K. H. KLOOS, and B. O. SCHWEIGHOEFER (Darmstadt, Technische Hochschule, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2179-2186.

In aircraft engines, titanium alloys are used as material for turbine blades in the fan area, on the basis of weight considerations. In such cases, fretting can lead to macrocracks which represent serious component defects. The present paper is concerned with a study of the fretting fatigue behavior of the alloy Ti-6Al-4V with the aid of a model apparatus. The approach employed in the study is based on the fretting bridge test principle. Attention is given to the fretting bridge arrangement, typical damage observed in the case of a specimen fractured in a fretting fatigue test, and the significance of the stress distribution in the system of specimen and fretting bridge. The investigation of the stress and slip distribution in the contact system specimen-fretting bridge is discussed, taking into account the finite element structure and stress distribution, the stress profile in the contact area of specimen and fretting bridge during a cycle of load, the distribution of slip between specimen and fretting bridge, and the material stressing in the contact area. G.R.

**A86-27492**

**NOISE IMMUNITY OF SIGNALS WITH MINIMUM FSK [POMEKHOUSTOICHIVOST' SIGNALOV S MINIMAL'NOI CHASTOTNOI MANIPULIATSIEI]**

A. I. LOGVIN and S. V. NEBUSEV Radiotekhnika (ISSN 0033-8486), Jan. 1986, p. 49-54. In Russian. refs

The Markov theory of optimal nonlinear filtering is used to synthesize a receiver scheme for minimum-FSK signals with random changes of the HF phase and signal delay. Formulas for estimating the noise immunity of the synthesized scheme are presented, and numerical-integration results are given. It is noted that the proposed scheme is suitable for satellite and aircraft communications systems. B.J.

**A86-27653#**

**A STUDY OF THE STATIC POST BUCKLING BEHAVIOR OF COMPOSITE SANDWICH PLATES**

S. HANAGUD, H. P. CHEN, and P. SRIRAM (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 13 p. refs

A static post buckling behavior of composite sandwich plates has been analyzed in this paper. A consistent and general three dimensional approach to the formulation has been presented. Finite deformations have been considered and a total Lagrangian approach has been used. Numerical solutions have been obtained by a discrete penalty function based finite element technique. A constant arc-length method has been used for equilibrium iterations to achieve faster convergence needed in post buckling studies. Author

**A86-27703**

**MECHANICAL DESIGN AND EVALUATION OF A SLOTTED CFRP WAVEGUIDE ANTENNA**

L. KNUTSSON, S. BRUNZELL, and H. MAGNUSSON (Ericsson Radio Systems, AB, Moelndal, Sweden) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 475-481.

A development program for a slotted waveguide array antenna made of metallized CFRP was carried out. The main objective was to minimize the weight of the structure without degrading the electrical and mechanical performance. This paper focuses on mechanical design aspects and manufacturing methods of metallized CFRP waveguides and assembly of an antenna array. A weight saving of approximately 40 percent was accomplished by the CFRP structure compared to a corresponding aluminum structure. Electrical properties and cost were essentially equal for the two concepts. Author

**A86-27741**

**AEROELASTIC TAILORING STUDY IN AIRCRAFT DESIGN**

T. UGAI, H. KIKUKAWA, J. TAKAKI (Fuji Heavy Industries, Ltd., Utsunomiya, Japan), M. SUNAKAWA, and Y. HIRANO (Tokyo, University, Japan) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1221-1232. Research sponsored by the Agency of Industrial Science and Technology.

A computer program to assist the tailoring of aeroelastic composite aircraft wing designs, the Composite Structure Multi-constrained Optimization System (COSMOS), is described. The program makes it possible to perform automatically repeated calculations of design constraints with respect to composite strength, deflection, flutter velocity, and vibration frequency. The main objective of the COSMOS program is the optimization of composite laminated structures, but the optimization of metal structures is also possible. In addition to the four main optimization criteria provided by COSMOS, future constraints on buckling, thermal stress, and fatigue will be incorporated in the future. In order to correlate the design constraints of the COSMOS program, a test prototype laminate structure was built and rigidity and vibration tests were carried out. The test results for strain and twist angle of the model structure are compared with COSMOS estimates in a table. I.H.

**A86-28276**

**STRUCTURAL IMPACT AND CRASHWORTHINESS; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON, ENGLAND, JULY 16-20, 1984. VOLUME 1 KEYNOTE LECTURES. VOLUME 2 - CONFERENCE PAPERS**

G. A. O. DAVIES, ED. and J. MORTON, ED. (Imperial College of Science and Technology, London, England) Conference sponsored by USAF, U.S. Army, Westland Helicopters, Ltd., and Imperial College of Science and Technology. London and New York, Elsevier Applied Science Publishers, 1984. Vol. 1, 269 p.; vol. 2, 578 p. No individual items are abstracted in these volumes.

In the present treatment, 'crashworthiness' is understood to mean the ability of land, sea and air vehicles to survive collision without unacceptable damage to payloads; the problem is therefore one of low-to-moderate velocity, and the amount of energy to be absorbed is a major parameter. 'Structural impact' is construed, however, as a more general term, encompassing many cases of high or low velocity impact between objects that may be vehicles, projectiles, ground installations, body armor, etc. Among the topics discussed are NASA research on crash dynamics, the scaling of inelastic structures, vehicle impacts and fire hazards, ballistic deformation, and impact and crashworthiness of composite structures. Also treated are topics in automobile and rail transport, concrete structures, aircraft impacts, fluid-structure interaction, composites, energy absorption, and blast and ballistic effects. O.C.

**A86-28303**

**PROBLEMS OF AIRCRAFT RELIABILITY [PROBLEMY NADEZHNOSTI LETATEL'NYKH APPARATOV]**

I. F. OBRAZTSOV, ED. and A. S. VOLMIR, ED. Moscow, Izdatel'stvo Mashinostroenie, 1985, 280 p. In Russian. For individual items see A86-28304 to A86-28322.

The papers presented in this volume provide an overview of current theoretical and experimental research in the field of aircraft reliability. Topics discussed include accelerated testing as a means of ensuring the reliability of aircraft equipment, reliability and maintenance of aircraft, optimum maintenance of aircraft systems on the basis of their condition with allowance for measurement errors, and deterministic and statistical models of durability. Papers are also presented on problems in the dynamics of aircraft structures exposed to intensive acoustic loading, optimal frequency of the periodic tests of on-board digital computers, and a combined optimal algorithm for filtering and calculating navigation coordinates. V.L.

**A86-28309**

**RELIABILITY AND MAINTENANCE OF AIRCRAFT [NADEZHNOST' I TEKHNICHESKAIA EKSPLUATATSIIA AVIATSIONNOI TEKHNIKI]**

V. V. FILIPPOV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 48-62. In Russian. refs

The relationship between the reliability of aircraft systems and the approach to their maintenance is examined, and various maintenance strategies are discussed. In particular, attention is given to maintenance programs based on the remaining life criterion, on the actual condition of the equipment, and on the level of reliability. The problem of determining the optimum periodicity of maintenance is also discussed. V.L.

**A86-28314**

**RELIABILITY OF THE PLATES AND SHELLS OF AIRCRAFT [NADEZHNOST' PLASTINOK I OBOLOCHEK LETATEL'NYKH APPARATOV]**

A. S. VOLMIR and S. A. TIMASHEV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 151-170. In Russian.

The reliability of the plate and shell structures of aircraft that are subjected during service to various types of loading, including axial compression, torque, and transverse loading, is investigated using a systems approach. The principal schemes for calculating the reliability of deformable systems are presented, and ways to control the reliability of mechanical systems are discussed. Particular attention is given to cases involving a decrease in the cross-sectional area of thin-walled aircraft structures or a deterioration of the physicomechanical properties of a structural material during service. V.L.

**A86-28315**

**APPLYING I. G. BUBNOV'S METHOD TO THE SOLUTION OF THE NATURAL VIBRATION PROBLEM FOR A CONICAL SANDWICH PANEL [PRIMENENIE METODA I. G. BUBNOVA K RESHENIIU ZADACHI O SVOBODNYKH KOLEBANIIAKH TREKHSLOINOI KONICHESKOI PANELI]**

E. I. GRIGOLIUK and E. A. LOPANITSYN IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 171-187. In Russian. refs

A direct variational approach is proposed for solving a problem concerning the natural vibrations of a conical sandwich panel with a stiff core loaded in shear. The eigenvalue problem is solved through simultaneous iteration; the convergence of the method is evaluated. V.L.

**A86-28316**

**PROBLEMS IN THE DYNAMICS OF AIRCRAFT STRUCTURES EXPOSED TO INTENSIVE ACOUSTIC LOADING [ZADACHI DINAMIKI KONSTRUKTSII LETATEL'NYKH APPARATOV PRI INTENSIVNYKH AKUSTICHESKIKH VOZDEISTVIIAKH]**

A. V. KARMISHIN and I. G. KILDIBEKOV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 188-203. In Russian. refs

The current theoretical and experimental research related to the strength of aircraft structures subjected to acoustic loading is briefly reviewed. In particular, attention is given to characteristics of the behavior of thin-walled structural elements under intensive acoustic loading, nonlinear characteristics of panels, and the effect of acoustic loading on the fatigue life and the bearing capacity of structural elements. The importance of considering acoustic loading in evaluating the reliability of aircraft structures is emphasized. V.L.

**A86-28318**

**DYNAMIC STABILITY OF ELASTIC STRUCTURES UNDER RANDOM INFLUENCES [DINAMICHESKAIA USTOICHIVOST' UPRUGIKH KONSTRUKTSII PRI SLUCHAINYKH VOZDEISTVIIAKH]**

B. P. MAKAROV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 223-235. In Russian. refs

The paper is concerned with problems of the stability and stochastic parametric oscillations of elastic structures that are represented as discrete systems. In particular, the spectra of the critical parameters are analyzed for the case of wide-band and narrow-band effects, and their asymptotic properties are determined. The flutter of a panel in the presence of fluctuations is analyzed as an example. V.L.

**A86-28319**

**THE LIFE OF REINFORCED THIN-WALLED STRUCTURES IN A RANDOM FORCE FIELD [DOLGOVECHNOST' TONKOSTENNYKH PODKREPLENNYKH KONSTRUKTSII V POLE SLUCHAINYKH SIL]**

V. N. MOSKALENKO IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 236-245. In Russian.

Solutions are presented for problems of the natural vibrations of periodic and quasi-periodic systems in gas flow, as well as problems concerned with the determination of the life of reinforced structures. The properties of the frequency spectra and of the modes of the natural vibrations of periodic and quasi-periodic systems are discussed. It is noted that excitation generally occurs at the frequencies corresponding to the pass band of the elastic skin and at the frequencies corresponding to the preferred vibrations of the acoustic volume. V.L.

**A86-28321**

**PROBLEMS IN THE STABILITY AND DYNAMICS OF AIRCRAFT STRUCTURES WITH PHYSICOMECHANICAL SINGULARITIES [ZADACHI USTOICHIVOSTI I DINAMIKI ELEMENTOV LETATEL'NYKH APPARATOV S FIZIKO-MEKHANICHESKIMI OSOBENNOSTIAMI]**

I. N. PREOBRAZHENSKII IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 252-262. In Russian.

A method for solving stability problems for stiffened structures is proposed which is based on the formalism of generalized, or impulsive functions. The method is illustrated for a hinged stiffened cylindrical panel with a damaged stiffening element and for a stiffened cylindrical shell. It is shown that in certain cases, the inhomogeneity of the stressed state due to a damage can be neglected in the general stability analysis of a structure. V.L.

**A86-28322**

**THE EFFECT OF CHANGES IN THE STATIC STRENGTH OF A STRUCTURE DURING SERVICE ON THE RELIABILITY OF AIRCRAFT [VLIIANIE IZMENENIIA STATICHESKOI PROCHNOSTI KONSTRUKTSII V PROTSESSE EKSPLUATATSII NA NADEZHNOST' LETATEL'NYKH APPARATOV]**

O. I. TEREBUSHKO IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 262-270. In Russian.

An approximate method is proposed for evaluating the effect of changes in the static strength of a structure during service on its reliability. Numerical calculations are presented which show that even a relatively small reduction in static strength can multiply the probability of failure. The effect of the variance coefficients of the initial strength and safety on the reliability is illustrated by examples. V.L.

**A86-28330**

### A FLEXIBLE PROGRAMMABLE SIGNAL PROCESSOR FOR NEXT GENERATION FIGHTER AIRCRAFT

R. ROWLETT, C. STEWART, and M. MAYOR (Sperry Corporate Technology Center, Reston, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 22-27. refs

The performance requirements of next generation Programmable Signal Processors (PSP) military radar applications are examined. Consideration is given to processor performance criteria (throughput rate, parameter changes, mode changes) in connection with several air-to-air radar modes including long range search, single target tracking, track-while-scan, and ECCM. Air-to-ground radar modes are also examined, with emphasis given to Moving Target Indication (MTI), Doppler mode, SAR, and terrain following/avoidance. It is shown that next-generation PSP will require processing speeds on the order of 1 billion complex operations per second. It is pointed out that conventional array processor architectures similar to those in current PSPs will need significantly larger memory bandwidths to achieve the required throughput rates. However, the use of parallel architectures such as systolic arrays and wavefront arrays can achieve such speeds with much lower memory bandwidth requirements. I.H.

**A86-28332**

### DIGITAL CHIRP DEMODULATION

C. F. ANDREN and M. A. KOMARA (Harris Corp., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 35-40.

The results of computer simulations of process of the digital chirp demodulation are presented. It is shown that digital chirp demodulation can be accomplished using 4-bit signal quantization provided that Gaussian-distributed dither is injected 15 dB below the full-scale level of the quantizer. Comparative results obtained with ramp-type dither showed unacceptable performance, as well as those using less than 4 bits of quantization and more or less dither. Functional block diagrams of analog and digital chirp demodulation processes are provided. I.H.

**A86-28338**

### FIBER OPTIC HIGH SPEED DATA BUS

R. MONING and G. HILL (Boeing Military Airplane Co., Wichita, KS) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 88-90.

R&D activity is discussed in connection with a fiber optic data bus architecture having 48 channels for transmission of 64 Kbps PCM voice data. The system consists of three remote terminals, a gateway terminal, and a 4-port star-coupled fiber optic data bus. Each terminal consists of an 8086 processor card which controls the terminal or gateway; a digital-to-analog converter; and an interface card which controls the fiber optic data bus. The data bus protocol for the system is described and a detailed schematic diagram of the protocol initialization sequence is provided. I.H.

**A86-28340**

### IMAGING CONNECTOR INTERCONNECT SYSTEM FOR A PARALLEL FIBER OPTIC DATA BUS

R. W. UHLHORN (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 95-102. Research supported by the Harris Corporation Independent Research and Development Fund.

A fiber optic data transfer system capable of transmitting high-speed parallel digital data is being developed. This system is part of a total network concept, known as the Distributed Memory Network (DMN), which has numerous aerospace applications and is directly applicable to bus networking requirements specified in the Advanced Systems Avionics (ASA) baseline. The data transfer system, which utilizes a new optical imaging connector, a multi-fiber transmission medium, and highly reliable electronic and electro-optic components is the heart of the DMN. Because of the very high data rates involved in future avionics systems, fiber optics is the only viable transmission medium, and the connector concept is the only practical way of achieving the required high-speed, high-density parallel interface. The present design is capable of transmitting 64-bit parallel data at word rates up to 128 megawords per second for an equivalent serial data rate of 8.192 Gbps. Author

**A86-28341**

### A ROBUST 100 MBPS NETWORK FOR AVIONICS APPLICATIONS

M. P. VARGA (Sperry Corp., Space Systems Div., Phoenix, AZ) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 103-111.

A fiber-optic Local Area Network that operates at a transmission rate of 100 MBPS is designed to feature advantages of random access (contention) networks and deterministic (token) networks. This LAN implements a contention access protocol that dynamically adjusts its performance to that of a token network as the data traffic increases. The statistical relationship between collisions and data traffic load is used to achieve this adjustment in performance. The network and bus interface units (BIUs) incorporate message fault recovery, system statistical monitor, built-in test, low power, high reliability, and radiation resistant features. The network and BIUs were designed to incorporate redundancy with cross-strapping at the physical media, and because the media is a broadcast media with simultaneous transmission over both fiber buses, immediate recovery or many physical layer failures is possible. System level redundancy is supported with BIU internal checks and an automatic switchover to redundant units. Author

**A86-28342**

### HIGH SPEED FIBER OPTIC DATA BUS FOR AVIONICS INTEGRATION

P. R. COUCH and K. D. FERRIS (FiberCom, Inc., Roanoke, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 114-121.
(Contract F33615-83-C-1036)

A review of the state-of-the-art of the various elements of a fiber optic data bus has been conducted. Based on the characteristics of the various components, an analysis of data bus system performance in an avionics integration application was performed. Technology/performance limits of the fiber optic data bus elements were combined with the avionics integration requirements to define the tradeoffs between topology, data rate, and number of terminals. The study concluded that fiber optic technology has matured to the point that, optical data buses supporting up to 128 terminals are feasible at data rates up to 300 Mb/s and that such buses will be key to avionics integration with future VHSIC computers and avionic sensors. Author

**A86-28343**

### HIGH SPEED BUS FOR PAVE PILLAR APPLICATIONS

M. T. LUDVIGSON and K. L. MILTON (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 122-129.

The status of development activity in connection with the USAF High Speed Bus Technology program is reviewed. Emphasis is given to wire bus designs with applications in Pave Pillar systems. The basic design requirements of a digital data bus are discussed with respect to optimum throughput rate; the optimum number of terminals; message length; and compatibility with fiber-optic media. Network topologies for the bus are described, with attention given to linear networks, active rings, and switched networks. Optimum protocols and message formats for the linear bus topology of the bus are discussed in detail. Functional block diagrams of the wire bus coupler, terminal, and control interfaces of the bus system are provided. I.H.

**A86-28344#**

### A DUAL CHANNEL HIGH SPEED FIBER OPTICS MULTIPLEX DATA BUS SYSTEM

H. J. ALBER and W. A. THOMAS (USAF, Systems Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 130-135.

This paper provides the framework for a candidate high speed data bus. The high speed data bus is intended for use with the next generation fighter and bomber aircraft. The bus system minimizes the transport delays, optimizes the efficiency of transporting data, and minimizes the control overhead. Manchester coding plus unique start and stop identifiers are used to minimize the complexity of the encoding and decoding electronics. The token passing and centralized bus management concepts provide a deterministic system that can rapidly respond to system faults. Fiber optic point-to-point links are used to minimize the risk in connector and transceiver development, while providing for a large number of users and relatively long distances between devices. Author

**A86-28372**

### CONTROL OF A HIGH-SPEED, BRUSHLESS DC MOTOR DRIVEN THROUGH A CYCLOCONVERTER LINE

J. J. CATHEY, D. B. REESOR (Kentucky, University, Lexington), and J. A. WEIMER (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 376-382. refs
(Contract F33615-81-C-201)

Feasibility and concept of designing a high-speed, permanent magnet, brushless dc motor aircraft fuel pump drive using a cycloconverter link is examined. Analytical methods are developed to model the behavior of a three-phase permanent magnetic machine when operated as a self-synchronous motor supplied from a polyphase, variable voltage, variable frequency source through a midpoint cycloconverter link under circulating current free mode of control. A hybrid combination of sinusoidal and dc steady-state analysis methods is utilized to obtain a suitable equivalent circuit of the motor. Study of the motor model is made to establish the nature of the no load MMF angle as a function of current to give a minimum value while assuring proper thyristor commutation. Then, a closed loop control system with an outer loop on speed and an inner loop on current is postulated wherein a proportional plus integral controller is placed in the forward path to assure minimum speed error. A numerical study of performance is presented for speed runup and rundown conditions. Author

**A86-28373**

### POWER THYRISTOR STARTER FOR AIRCRAFT ENGINE

Z. CAI (Purdue University, West Lafayette, IN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 383-390.

A power thyristor starter for powerful aircraft engine is introduced. Some problems which appeared during the industrial testing are analyzed. The technology-economy indices of this device were verified by the experimental curves and by comparing with those of the internal-combustion engine-dc generator power-supply vehicle. Author

**A86-28376**

### MULTIVOLTAGE HIGH POWER ELECTRICAL POWER SYSTEM

W. E. HYVARINEN (Westinghouse Electric Corp., Pittsburgh, PA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 407-412.

Applications are being identified where the optimum aircraft electrical system may not be the conventional 400 Hz approach. The requirements for a multivoltage high power airborne electrical system are presented. The methodology used to define and evaluate operating parameters, system configuration and control philosophy are presented. The approach recommended for this application is described. Author

**A86-28479**

### IMPROVED RELIABILITY OF ELECTRONIC CIRCUITS THROUGH THE USE OF HEAT PIPES

A. BASIULIS and C. P. MINNING (Hughes Aircraft Co., Culver, City, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1244-1247.

The increase in power dissipation of new avionic circuits is applying ever higher demands on the ability of conventional cooling systems to maintain circuit temperatures at accepptable levels. Since the failure rate of an electronic component is strogly temperature dependent, the design of avionics systems is often times limited by thermal considerations. In a sidewall cooled avionics chassis such as that described in MIL-STD-XXX, temperatures of PWB mounted electronic components can be reduced significantly if heat pipes instead of solid metal plates are used to transport electronic-component generated heat to the cooled sidewalls. To demonstrate this results, experimental testing of heat pipe cooled PWBs was combined with thermal analysis to show that the mean time between failure (MTBF) of an advanced bulk memory can be increased by up to 60 percent if heat pipes are used in place of solid metal plates. Author

**A86-28492#**

### DIAGNOSIS - USING AUTOMATIC TEST EQUIPMENT AND ARTIFICIAL INTELLIGENCE EXPERT SYSTEMS

J. E. RAMSEY, JR. (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1369-1374. USAF-supported research.

Three expert systems (ATEOPS, ATEFEXPERS, and ATEFATLAS), which were created to direct automatic test equipment (ATE), are reviewed. The purpose of the project was to develop an expert system to troubleshoot the converter-programmer power supply card for the F-15 aircraft and have that expert system direct the automatic test equipment. Each expert system uses a different knowledge base or inference engine, basing the testing on the circuit schematic, test requirements document, or ATLAS code. Implementing generalized modules allows the expert systems to be used for any different unit under test. Using converted ATLAS to LISP code allows the expert system to direct any ATE using ATLAS. The constraint propagated frame system allows for the expansion of control by creating the ATLAS code, checking the code for good software engineering techniques, directing the ATE, and changing the test sequence as needed (planning). D.H.

**A86-28551#**

**CONTACT HEAT TRANSFER - THE LAST DECADE**

C. V. MADHUSUDANA (New South Wales, University, Kensington, Australia) and L. S. FLETCHER (Texas A&M University, College Station) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 510-523. refs

Thermal contact conductance should be high in such applications as nuclear reactors, gas tubines, aircraft structural joints, etc.; when mechanically strong insulation is required, by contrast, as in the storage of cryogenic liquids, contact resistance must be as high as possible. Attention is presently given to the results obtained since 1970 by theoretical and experimental studies of conduction through contact spots and through interstitial materials. Special problems that are introduced by the geometry of contact, load cycling, and heat flux, are also discussed. Recommendations are made concerning the most fruitful directions for future investigation. O.C.

**A86-28553#**

**MATERIAL CONTRAVARIANT COMPONENTS - VORTICITY TRANSPORT AND VORTEX THEOREMS**

L. MORINO (Boston University, MA) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 526-528. refs
(Contract DAAG26-83-K-0050)

The concept of material contravariant components of the vorticity in a convected curvilinear coordinate system is introduced in order to interpret classical vortex theorems. For the case of inviscid isentropic flows, the material contravariant components of the vorticity divided by the density are constant, following a material point. This result simplifies the proof and the kinematic interpretation of classical results. The present result is then extended to general viscous nonisentropic flows, and used to obtain a simple but powerful computational scheme for the solution of Beltrami's vorticity equation. O.C.

**A86-28570*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**CRYOGENIC TUNNEL MEASUREMENT OF TOTAL TEMPERATURE AND PRESSURE**

W.-F. NG and J. C. ROSSON (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 244-249. Research supported by George Washington University and NASA. refs

A newly developed, 3-mm-diam, dual hot-wire aspirating probe was used to measure the time-resolved stagnation temperature and pressure in a transonic cryogenic wind tunnel. Measurements were taken in the freestream of the settling chamber and test section. Data were also obtained in the unsteady wake shed from an airfoil oscillating at 5 Hz. The investigation revealed the presence of large fluctuations in the settling chamber occuring at the blade passing frequency of the driving fan of the tunnel. These fluctuations decrease at the test section. The rms value of the fluctuating stagnation pressure decreased from 17.5 percent in the settling chamber to 3.7 percent in the test section. Fluctuating stagnation temperature decreased from 12.3 percent to 8.4 percent. Measurements in the wake of the oscillating airfoil showed a fluctuating stagnation temperature of as much as 42 K in rms value. Author

**A86-28651**

**ADVANCES IN AEROSPACE STRUCTURAL ANALYSIS; PROCEEDINGS OF THE WINTER ANNUAL MEETING, MIAMI BEACH, FL, NOVEMBER 17-22, 1985**

O. H. BURNSIDE, ED. and C. H. PARR, ED. (Southwest Research Institute, San Antonio, TX) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers , 1985, 152 p. For individual items see A86-28652 to A86-28663.

The present conference considers the uncertain eigenvalue analysis of composite laminated plates by stochastic FEM, probabilistic finite elements for transient analysis in nonlinear continua, the numerical synthesis of trivariate velocity realizations of turbulence, efficient algorithms applicable to probabilistic finite element analysis, a stochastic model for fatigue crack growth rate, and the demonstration of a novel fast probability integration method for reliability analysis. Also discussed are advanced reliability methods for structural evaluation, probabilistic structural analysis for spacecraft propulsion system components, the prediction of micromechanical properties in flexible matrix composites, the limitations of finite elements in orthotropic laminated beam analysis, a case study of cure cycle shrinkage deformations, and mixed finite element models for laminated composite plates. O.C.

**A86-28654*#** Rice Univ., Houston, Tex.

**NUMERICAL SYNTHESIS OF TRI-VARIATE VELOCITY REALIZATIONS OF TURBULENCE**

P.-T. D. SPANOS (Rice University, Houston, TX) and K. P. SCHULTZ (Lockheed Engineering and Management Services Co., Houston, TX) IN: Advances in aerospace structural analysis; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 25-35. refs
(Contract NAG3-210)

An approach for synthesizing trivariate turbulence velocity field spatial realizations is presented. Some of the spatial frequency characteristics of the random velocity field are described by the von Karman spectrum. The simulation algorithm is based on an efficient autoregressive-moving average (ARMA) scheme involving coefficient square matrices of order three. The determination of the efficient low order ARMA algorithm is preceded by the determination of a suitable high order autoregressive (AR) simulation algorithm. The numerical results are presented in a dimensionless form. Thus, they are applicable for any scale of turbulence. Author

**A86-28666#**

**TAIL PROFILE EFFECTS ON UNSTEADY LARGE SCALE FLOW STRUCTURE IN THE WING AND PLATE JUNCTION**

E. P. ROOD and D. G. ANTHONY (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Forum on unsteady flow - 1985; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 30-32. Navy-sponsored research.

Mean velocity contours and flow separation patterns for two tail profiles, a 28 degree circular arc and an NACA 0020, are measured to determine the characteristics of the unsteady large scale flow structure associated with the wing and plate junction. Data indicate that the pressure recovery at the tail of the wing, immersed in the otherwise steady boundary layer, is especially significant in determining the downstream dynamic vortex-wake-boundary layer interaction. It is found that adverse pressure gradients produce rapid growth of the across-stream spatial extent of the vortex legs, and that vortex rollup, which contributes to the spatial extent of the unsteadiness of the vortex legs, is indicated by the curved separation line along the wing trailing edge inside the boundary layer. R.R.

**A86-28742**

**LINEAR AND NONLINEAR MODAL ANALYSIS OF AEROELASTIC STRUCTURAL SYSTEMS**

R. A. IBRAHIM (Texas Tech University, Lubbock) and T. D. WOODALL (Sandia National Laboratories, Albuquerque, NM) Computers and Structures (ISSN 0045-7949), vol. 22, no. 4, 1986, p. 699-707. refs

This paper deals with the investigation of linear modal analysis and the autoparametric interaction of aeroelastic systems. The normal-mode frequencies and the associated mode shapes are obtained in terms of the system parameters. The main objective of the linear analysis is to explore the critical regions of autoparameteric (or internal) resonance conditions, Sum(k-i omega-i) = 0 (where k-i are integers and omega-i are the normal-mode frequencies). The results show that for certain system parameters the condition of internal resonance is satisfied. The dynamic behavior of the structure in the neighborhood of internal-resonance conditions is obtained by considering the nonlinear coupling of the normal modes. Under certain conditions the steady-state response is derived analytically for the sum internal-resonance condition. It is concluded that the nonlinear modal analysis reveals certain types of response characteristics which cannot be interpreted within the framework of the linear theory of small oscillations. Author

**A86-29011*** Bettis Atomic Power Lab., West Mifflin, Pa.
**REFERENCES AND CONFERENCE PROCEEDINGS TOWARDS THE UNDERSTANDING OF FRACTURE MECHANICS**
P. M. TOOR (Bettis Atomic Power Laboratory, West Mifflin, PA) and C. M. HUDSON (NASA, Langley Research Center, Hampton, VA) Journal of Testing and Evaluation (ISSN 0090-3973), vol. 14, March 1986, p. 61-75. refs

A list of books, reports, periodicals, and conference proceedings, as well as individual papers, centered on specific aspects of fracture phenomenon has been compiled by the ASTM Committee E-24 on Fracture Testing. A list of basic references includes the articles on the development of fracture toughness, evaluation of stress intensity factors, fatigue crack growth, fracture testing, fracture of brittle materials, and fractography. Special attention is given to the references on application of fracture mechanics to new designs and on reevaluation of failed designs, many of them concerned with naval and aircraft structures. I.S.

**A86-29471**
**NUMERICAL METHODS IN FLUID DYNAMICS**
F. BREZZI, ED. (Pavia, Universita, Italy) Berlin and New York, Springer-Verlag (Lecture Notes in Mathematics. Volume 1127), 1985, 341 p. For individual items see A86-29472 to A86-29475.

The present conference on fluid dynamics applications of numerical methods considers finite element, least squares and domains-decomposition methods for the numerical solution of nonlinear fluid dynamics problems, as well as the Galerkin, Chebyshev and Legendre spectral approximation methods. Also discussed are recent advancements in computational aerodynamics for transonic flow aircraft calculations, and the particle method's approximation of the Euler equations as well as its application to two- and three-dimensional vortex methods. O.C.

**N86-20658#** Analytic Sciences Corp., Reading, Mass.
**INTEGRATED COMMUNICATION, NAVIGATION, AND IDENTIFICATION AVIONICS: IMPACT ANALYSIS. EXECUTIVE SUMMARY Final Report, Mar. 1982 - Mar. 1984**
M. H. VEATCH and J. C. MCMANUS Oct. 1985 16 p
(Contract F33615-82-C-0002)
(AD-A161799; AFHRL-TP-85-20) Avail: NTIS HC A02/MF A01
CSCL 17B

This paper summarizes the approach and findings of research into reliability, supportability, and survivability prediction techniques for fault-tolerant avionics systems. Since no technique existed to analyze the fault tolerance of reconfigurable systems, a new method was developed and implemented in the Mission Reliability Model (MIREM). The supportability analysis was completed by using the Simulation of Operational Availability/Readiness (SOAR) model. Both the Computation of Vulnerable Area and Repair Time (COVART) model and FASTGEN, a survivability model, proved valuable for the survivability research. Sample results are presented and several recommendations are also given for each of the three areas investigated under this study: relaibility, supportablility and survivability. GRA

**N86-20671*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**PIEZOELECTRIC DEICING DEVICE Patent**
R. C. FINKE and B. A. BANKS, inventors (to NASA) 8 Oct. 1985 5 p Filed 7 Aug. 1984 Continuation of abandoned US-Patent-Appl-SN-469867, filed 25 Feb. 1983
(NASA-CASE-LEW-13773-2; US-PATENT-4,545,553;
US-PATENT-APPL-SN-638541; US-PATENT-CLASS-244-134-D;
US-PATENT-CLASS-39-25.35; US-PATENT-CLASS-310-324)
Avail: US Patent and Trademark Office CSCL 09A

A fast voltage pulse is applied to a transducer which comprises a composite of multiple layers of alternately polarized piezoelectric material. These layers are bonded together and positioned over the curved leading edge of an aircraft wing structure. Each layer is relatively thin and metallized on both sides. The strain produced in the transducer causes the composite to push forward resulting in detachment and breakup of ice on the leading edge of the aircraft wing.
Official Gazette of the U.S. Patent and Trademark Office

**N86-20677#** National Aerospace Lab., Tokyo (Japan).
**COVARIANCE SPECIFICATION FOR THE LINEAR TIME-INVARIANT OUTPUT-FEEDBACK CONTROL SYSTEMS USING A KALMAN FILTER**
M. NAGAYASU 1985 16 p refs In JAPANESE; ENGLISH summary
(NAL-TR-862; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The covariance specification problem using a Kalman filter for the linear time-invariant output-feedback control system contaminated by observation and system noise is described. The optimal output-feedback control using a Kalman filter with which the stationary state covariance matrix coincides with the prescribed matrix is discussed. The system is disturbed by additive white/color system noise and the output signal is contaminated by white observation noise. Using a Kalman filter, the dynamic output feedback control system was obtained. The covariance specification problem, i.e., to obtain the optimal feedback gains under the requirements of the state covariance coinciding with the prescribed covarience for minimizing the control effort, is solved. The control problem of an aircraft in the atmospheric turbulence is discussed as a numerical example. Author

**N86-20759#** National Aerospace Lab., Tokyo (Japan).
**STUDY ON THE DIGITAL POSITION TRANSDUCER WITH OPTICAL TIME-DELAY PULSE**
M. MAYANAGI 1985 40 p refs In JAPANESE; ENGLISH summary
(NAL-TR-878; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A rotary optical position transducer employing a pulse technique time delay multiplexor was studied during the development of a Fly-By-Light (FBL) for the aircraft control system, the aim of which is to offer inherent resistance to environments of electromagnetic interference (EMI), electromagnetic pulse (EMP) and lightning. The conventional absolute type optical digital transducer causes difficulty in the interface technique between the transducer and other devices such as a computer. The transducer system described consisting of a rotary position transducer unit, fiber optic cable, light source unit, and electronics interface unit, can improve this interface technique. The rotary transducer unit is an electrically passive device connected through optical fibers to the light source unit and electronics interface unit, and has many advantages of fiber optic techniques. Basic problems in the development of the rotary transducer system were studied. In particular, a basis for optimizing illumination irradiance and photodetector characteristics is given, and the intrinsic performance of the transducer is quantitatively examined. Author

**N86-20797*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SEGMENTED TUBULAR CUSHION SPRINGS AND SPRING ASSEMBLY Patent Application**
L. A. HASLIM, inventor (to NASA) 18 Jun. 1985 39 p
(NASA-CASE-ARC-11349-1; NAS 1.71:ARC-11349-1;
US-PATENT-APPL-SN-746160) Avail: NTIS HC A03/MF A01
CSCL 13E

A spring which includes a tube with an elliptical cross section, with the greater axial dimension extending laterally and the lesser axial dimension extending vertically is disclosed. A plurality of cuts in the form of slots passing through most of a wall of the tube extend perpendiculary to a longitudinal axis extending along the tube. An uncut portion of the tube wall extends along the tube for bonding or fastening the tube to a suitable base, such as a bottom of a seat cushion. NASA

**N86-20813*#** Naval Postgraduate School, Monterey, Calif.
**PROCEEDINGS OF THE 1985 ONR/NAVAIR WAVE ROTOR RESEARCH AND TECHNOLOGY WORKSHOP Final Report, 1 Jan. - 31 Mar. 1985**
R. P. SHREEVE and A. MATHUR May 1985 425 p Workshop held in Monterey, Calif., 26-27 Mar. 1985
(Contract RR0-2403)
(AD-A161539; NPS67-85-008) Avail: NTIS HC A18/MF A01 CSCL 21E

The purpose of this workshop was to bring together an international group who are, or who have been, involved in research studies or applications of gas-gas, or gas-shaft, energy exchange through wave propagation in rotor passages. It is intended that the workshop serve to define the current levels of understanding, capability and interest in the field, and to provide the input necessary for an assessment of the prospects for the useful exploitation of wave rotors in gas turbine engines. GRA

**N86-20864#** National Aerospace Lab., Tokyo (Japan).
**FUNDAMENTAL INVESTIGATION ON THE IMPACT STRENGTH OF HOLLOW FAN BLADES**
T. IKEDA, T. MIYACHI, and Y. SOFUE 1985 23 p refs In JAPANESE; ENGLISH summary
(NAL-TR-879; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

Models of hollow fan blades were made and tested to prove that their strength is sufficient for use in real engines. The hollow blades were fabricated by diffusion bonding of two titanium alloy (6Al-4V-Ti) plates, one of which had three spanwise stiffners and the other being flat plate. The model as a nontwisted tapered blade. Impact tests were carried out on the hollow fan blade models in which the ingestion of a 1.5 pounds bird was simulated. Solid blades with the same external form were also tested by similar methods for comparison. The results of these tests show that properly designed hollow blades have sufficient stiffness and strength for use as fan blades in the turbo-fan engine. Author

**N86-21723#** Joint Publications Research Service, Arlington, Va.
**JAPAN REPORT: SCIENCE AND TECHNOLOGY**
10 Jan. 1986 59 p refs Transl. into ENGLISH from various Japanese articles
(JPRS-JST-86-001) Avail: NTIS HC A04/MF A01

Progress in Japanese science and technology is reported. Topics discussed include: aerospace sciences, chemical engineering, energy, nuclear development, and science and technology policies.

**N86-21755*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**PROGRAMMABLE, AUTOMATED TRANSISTOR TEST SYSTEM**
L. V. TRUONG and G. R. SUNDBURG 1986 25 p refs Presented at the 3rd Symposium on Space Nuclear Power Systems, Albuquerque, N. Mex., 13-16 Jan. 1986
(NASA-TP-2554; E-2768; NAS 1.60:2554) Avail: NTIS HC A02/MF A01 CSCL 09A

A programmable, automated transistor test system was built to supply experimental data on new and advanced power semiconductors. The data will be used for analytical models and by engineers in designing space and aircraft electric power systems. A pulsed power technique was used at low duty cycles in a nondestructive test to examine the dynamic switching characteristic curves of power transistors in the 500 to 1000 V, 10 to 100 A range. Data collection, manipulation, storage, and output are operator interactive but are guided and controlled by the system software. Author

**N86-21916#** LTV Aerospace Corp., Dallas, Tex.
**LAMINATED DAMPED FUSELAGE STRUCTURES**
R. A. ELY *In* AFWAL Vibration Damping 1984 Workshop Proceedings 32 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

The application of constrained layer damping, in the form of laminated skins, frames, and equipment racks, to control acoustic fatigue of structures and vibration of equipment in the aft fuselage sections of large aircraft is discussed. It is shown that the influence of constrained layer damping on the response of a honeycomb panel at its critical frequency is very different from the influences on its resonant responses. The discussed baseline data and background methodology include: laboratory characterization of materials, acoustical fatigue tests of baseline and laminated structures, peculiarities of structures with high damping, influences of various boundary conditions on damped panels, dynamic versus static stiffness of damped panels, and comparisons of predicted and measured stresses in damped and undamped panels that are representative of aircraft structures. Advanced metallic technology and constrained layer damping are utilized to redesign the A-7 center section leading edge flap and the F-111 outboard spoiler to achieve large increases in their acoustical fatigue lives. E.A.K.

**N86-21917#** Boeing Co., Seattle, Wash.
**BEAM DAMPERS FOR SKIN VIBRATION AND NOISE REDUCTION IN THE 747**
R. N. MILES *In* AFWAL Vibration Damping 1984 Workshop Proceedings 17 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

A special constrained layer damper was incorporated into the Boeing 747 upper deck fuselage structure. The damper replaces a rivetted stiffener which was installed to reduce noise levels inside the cabin. It was found that the damper installation produced a noise reduction equal to that achieved by the stiffener and resulted in an $8000 per airplane cost savings and a 130 pound per airplane weight savings. The analysis and test that led to this design are reviewed. E.A.K.

**N86-21918#** Boeing Military Airplane Development, Seattle, Wash.
**INTEGRATED DAMPED FUSELAGE STRUCTURE**
L. M. BUTZEL *In* AFWAL Vibration Damping 1984 Workshop Proceedings 29 p Nov. 1984
(Contract F33615-79-C-3206)
Avail: NTIS HC A99/MF A01 CSCL 20K

A program aimed at developing design guidelines for viscoelastic damping applied to skin-stringer-frame type aerospace structure is described. Periodic structure type response models were developed. Two procedures for assigning values of the damping parameters required in these models are presented. Results of test to develop and verify the damping parameter assignment procedure and response prediction models are discussed. The current status of these efforts is: (1) response models are yielding predictions in agreement with test results; (2) the damping parameter assignment procedures are working, however, more work is needed to bring them up to the confidence level of the response models. E.A.K.

**N86-21919#** Cabot Corp., Indianapolis, Ind. E-A-R Div.
**USE OF SKIN DAMPING TREATMENTS TO CONTROL AIRFRAME DYNAMIC RESPONSE FOR INTERIOR NOISE CONTROL**
C. I. HOLMER *In* AFWAL Vibration Damping 1984 Workshop Proceedings 19 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

A conceptual model for airframe and interior trim dynamic response. The model suggests that skin response in the frequency range may be affected by skin damping treatments. It is suggested that this motion is of significance in producing interior noise. Laboratory data of system loss factors for a new constrained layer, skin damping treatment show improved damping performance at lighter weight than other commercially available skin damping materials. Experimental data on an effective skin damping treatment which produces system loss factors which contribute significantly to total losses in the airframe in the presence of other loss mechanisms associated with the outfitted airframe are presented. The effective skin damping treatment reduces airframe motion at representative trim panel attachment points, suggesting role in the reduction of aircraft interior noise. E.A.K.

**N86-21923#** Lockheed-California Co., Burbank.

**A DESIGN GUIDE FOR DAMPING OF AEROSPACE STRUCTURES**

J. SOOVERE, M. L. DRAKE (Dayton Univ., Ohio), and V. R. MILLER (Air Force Wright Aeronautical Lab., Wright-Patterson AFB, Ohio) *In* AFWAL Vibration Damping 1984 Workshop Proceedings 9 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

The effectiveness of polymeric damping materials in controlling resonant vibration problems has been established through many successful applications. The area of these applications range from aircraft structures to jet engine structures. The development of a viscoelastic damping design guide for use by designers is outlined. A brief outline of this effort is presented. E.A.K.

**N86-21933*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FULL-SCALE TRANSPORT CONTROLLED IMPACT DEMONSTRATION**

R. J. HAYDUK, comp. Jan. 1986 356 p refs Workshop held in Hampton, Va., 10 Apr. 1985; sponsored by NASA. Langley Research Center and FAA
(NASA-CP-2395; L-16048; NAS 1.55:2395) Avail: NTIS HC A16/MF A01 CSCL 20K

The controlled impact demonstration (CID) test of a transport aircraft took place on December 1, 1984, crashing at a prepared site on Rogers Dry Lakebed, Edwards Air Force Base, California. The demonstration was a setback for the antimisting kerosene (AMK) researchers. The impact conditions, considerably different from the planned scenario, exposed large quantities of degraded AMK and hydraulic fluid and caused unexpectedly hot ignition sources, bulk loss of fuel from the right wing, airflow patterns over the wings and fuselage that were untested on AMK, and fuel intrusion into the lower fuselage. The test was much more severe than planned and is generally considered to be unrepresentative of the type of survivable crash that would benefit from AMK. Ninety-seven percent of the sensors on the fuselage and wing structure, seats, dummies, restraint systems, galley, and bins were active at impact. A wealth of sensor data was collected from this once-in-a-lifetime research test. The flight data recorder experiments on board were also generally successful.

**N86-21934*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CID OVERVIEW**

R. J. HAYDUK *In its* Full-Scale Transport Controlled Impact Demonstration p 1-16 Jan. 1986 refs
Avail: NTIS HC A16/MF A01 CSCL 20K

On December 1, 1984, NASA and the Federal Aviation Administration (FAA) conducted the first remotely piloted air-to-ground crash test of a transport category aircraft. The Full-Scale Transport Controlled Impact Demonstration (CID) was the culmination of 4 years of effort by the two agencies. NASA and the FAA had many objectives during the joint planning and execution of the Controlled Impact Demonstration. The structural loads experiment was very successful. Ninety-seven percent of the channels were active at impact. The data is still being assessed. Only a portion of the data is presented here; approximately 80 channels of data are available. Analysis of the remaining data is in progress. Interior photography was also very successful. One hundred percent of the cameras functioned. The film contains unique information on the development of fire and smoke in the interior of the aircraft. From a human tolerance point of view, the CID was simulation of a survivable crash. R.J.F.

**N86-21935*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**CID FLIGHT/IMPACT**

R. BARBER *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 17-28 Jan. 1986
Avail: NTIS HC A16/MF A01 CSCL 20K

The planned versus the actual results of the controlled impact demonstration of a transport aircraft are discussed. Remote control systems, site selection, manned flight tests, and wreckage distribution are discussed. R.J.F.

**N86-21936*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**NASA EXPERIMENTS ON THE B-720 STRUCTURE AND SEATS**

E. ALFARO-BOU *In its* Full-Scale Transport Controlled Impact Demonstration p 29-47 Jan. 1986
Avail: NTIS HC A16/MF A01 CSCL 20K

Two experiments onboard a remotely piloted transport aircraft that was crashed on landing are discussed. The structural experiment deals with the location and distribution of the instrumentation throughout the airplane structure. In the seat experiment, the development and testing of an energy absorbing seat are discussed. The objective of the structural experiment was to obtain a data base of structural crash loads for use in the advancement of crashworthy technology of materials (such as composites) in structural design and for use in the comparison between computer and experimental results. The objective of the seat experiment was to compare the performance of an energy absorbing transport seat and a standard seat when subjected to similar crash pulses. Details are given on the location of instrumentation, on the dynamic seat test pulse and headward acceleration limits. R.J.F.

**N86-21937*#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.

**CONTROLLED IMPACT DEMONSTRATION SEAT/CABIN RESTRAINT SYSTEMS: FAA**

R. A. JOHNSON *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 49-60 Jan. 1986
Avail: NTIS HC A16/MF A01 CSCL 20K

The FAA restraint system experiments consisted of 24 standard and modified seats, 2 standard galleys and 2 standard overhead compartments. Under the controlled impact demonstration (CID) program, the experimental objective was to demonstrate the effectiveness of individual restraint system designs when exposed to a survivable air-to-ground impact condition. What researchers were looking for was the performance exhibited by standard and modified designs, performance differences resulting from their installed cabin location, and interrelating performance demonstrated by test article and attaching floor and/or fuselage structure. The other restraint system experiment consisted of 2 standard overhead stowage compartments and 2 galley modules. Again, researchers were concerned with the retention of stowed equipment and carry-on articles. The overhead compartments were loaded with test weights up to their maximum capacity, and each of the galleys was filled with test articles: aft with normal galley equipment, forward with hazardous material test packages. A breakdown of instrumentation and distribution is given beginning with 11 instrumented type anthropomorphic dummies and 185 sensors which provided for acceleration and load measurements at the various experiment and associated structure locations. The onboard cameras provided additional coverage of these experiments, including the areas of cabin which were not instrumented. Test results showing the window-side leg forces versus pulse duration are given. R.J.F.

**N86-21939*#** PRC Kentron, Inc., Hampton, Va.

**NASA SEAT EXPERIMENT AND OCCUPANT RESPONSES**

E. L. FASANELLA *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 79-89 Jan. 1986 refs
Avail: NTIS HC A16/MF A01 CSCL 20K

Results of the crash test of a remotely piloted transport aircraft instrumented to measure a NASA energy-absorbing transport seat are given. Human tolerance limits to acceleration and a dynamic response index model are discussed. It was found that the acceleration levels at the rear of the airplane were quite low and were below the stroking threshold of the NASA EA-seat. Therefore, dummies in the standard and EA-seat responded approximately the same. All longitudinal accelerations were quite low for the primary impact with very low forces measured in the lap belts. The vertical (spineward) acceleration levels measured in the dummies were also relatively low and very survivable from an impact tolerance standpoint. The pilot with an 18 G peak acceleration received by far the highest vertical acceleration and could have possibly received slight spinal injury. R.J.F.

**N86-21940*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**STRUCTURAL LOADS PRELIMINARY RESULTS**
E. ALFARO-BOU *In its* Full-Scale Transport Controlled Impact Demonstration p 91-102 Jan. 1986
Avail: NTIS HC A16/MF A01 CSCL 20K

From a total of 351 instrumentation channels, 341 channels (97%) were in operation during the initial impact of the airplane. Both NASA seats, the energy absorbing seat and the standard seat, maintained their integrity during the impact. The floor accelerations at the seat locations were lower than the accelerations required for the energy absorbers to stroke; consequently, the energy absorbing seat did not stroke. The two seats remained firm in place during the crash and no seat attachment failures were observed. Due to the low accelerations experienced during the crash, both seats performed as standard seats. In the airplane structure, the accelerations were higher at both the point of impact in the left wing and at the forward end of the fuselage. The accelerations on the floor were higher toward the front than toward the rear and the floor accelerations on the left side were higher than on the right side at the front of the fuselage, but toward the rear they evened out. Author

**N86-21942*#** Simula, Inc., Phoenix, Ariz.
**PRELIMINARY FLOOR, SEAT, AND DUMMY DATA**
M. R. CANNON and R. E. ZIMMERMAN *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 125-155 Jan. 1986 refs
Avail: NTIS HC A16/MF A01 CSCL 20K

According to preliminary examination of the data, out of 179 data channels that were onboard the aircraft in support of the seat experiments, there is data from 168. There was somewhat more severe environment imposed in the structure of the obstacles than by the ground impact. Therefore, both ground impact and obstacle impact are of interest for crashworthiness experiments. Most of the data channels that were studied are fairly consistent with the physical evidence: they show acceleration levels that are reasonable, and in many cases those integrate out to a reasonable velocity change. Finally, from observation thus far, the ground impact did not fail or significantly damage any seat. Nor did any of the energy absorbers in the modified seats extend. The accelerations do not appear high enough and/or energetic enough to cause this to happen. At this time, the onboard films have not been studied; only some videotape have been viewed. Some of the seats were so badly damaged by the fire that any failures which might have occurred were obscured. A close examination of the onboard films using a stop-action projector will allow a more thorough evaluation. Author

**N86-21943*#** Federal Aviation Administration, Long Beach, Calif.
**CONTROLLED IMPACT DEMONSTRATION AIRFRAME BENDING BRIDGES**
S. J. SOLTIS *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 157-179 Jan. 1986
Avail: NTIS HC A16/MF A01 CSCL 20K

The calibration of the KRASH and DYCAST models for transport aircraft is discussed. The FAA uses computer analysis techniques to predict the response of controlled impact demonstration (CID) during impact. The moment bridges can provide a direct correlation between the predictive loads or moments that the models will predict and what was experienced during the actual impact. Another goal is to examine structural failure mechanisms and correlate with analytical predictions. The bending bridges did achieve their goals and objectives. The data traces do provide some insight with respect to airframe loads and structural response. They demonstrate quite clearly what's happening to the airframe. A direct quantification of metal airframe loads was measured by the moment bridges. The measured moments can be correlated with the KRASH and DYCAST computer models. The bending bridge data support airframe failure mechanisms analysis and provide residual airframe strength estimation. It did not appear as if any of the bending bridges on the airframe exceeded limit loads. (The observed airframe fracture was due to the fuselage encounter with the tomahawk which tore out the keel beam.) The airframe bridges can be used to estimate the impact conditions and those estimates are correlating with some of the other data measurements. Structural response, frequency and structural damping are readily measured by the moment bridges. R.J.F.

**N86-21944*#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.
**CONTROLLED IMPACT DEMONSTRATION FLIGHT DATA RECORDERS/COCKPIT VOICE RECORDERS**
L. J. GARODZ *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 181-193 Jan. 1986 refs
Avail: NTIS HC A16/MF A01 CSCL 20K

It was found that the sampling rates from flight recorders on a remotely piloted transport aircraft that crashed into the ground were too low, although they were higher than those required now by regulations. For example, the sampling rate for roll angle was one per second. The sampling rate for normal acceleration was also fairly low. Existing regulations require only 4 samples per second; researchers had 16 samples per second. Some data was lost during the initial impact. The frequency response data was adequate. R.J.F.

**N86-21945*#** Naval Air Test Center, Patuxent River, Md.
**UNITED STATES NAVY - CANADIAN FORCES SOLID STATE FLIGHT DATA RECORDER/CRASH POSITION LOCATOR EXPERIMENT ON THE B-720 CONTROLLED IMPACT DEMONSTRATION**
D. M. WATTERS *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 195-208 Jan. 1986
Avail: NTIS HC A16/MF A01 CSCL 20K

The operation of a radio beacon position locator during and after the remotely controlled transport aircraft is discussed. The radio beacon transmission was actuated and was picked up by the Navy P-3A chase aircraft for a short time, after which reception was lost. The pilot reported that he received a signal on both 121.5 MHz and 243 MHz for a period of approximately 5 seconds. Five minutes after the crash a portable direction finding unit located on the roof of the NASA Dryden Flight Research Facility, 4 miles distant from the crash, was unable to pick up the beacon transmission. The fire crews started fighting the fires approximately 90 seconds after the time of impact. Navy personnel access to the crash site was allowed on the morning of December 2, 1984. Radio beacon locator was found resting top side up, 15 feet forward and 13 feet perpendicular from the tray location the starboard side of the aircraft. An immediate inspection indicated the airfoil suffered moderate fire damage with paint peeling but not intumescing. The visual marker strobe lamp housings were intact but extensively burned such that it was impossible to see if the lamps had survived. The airfoil suffered minor structural damage, with assorted dents, etc. The extended plunger on the ARU-21 release unit indicated that the pyrotechnic deployment system operated. The radio beacon base (tray) suffered some heat and fire damage, and was charred and blackened by smoke. The frangible switch in the nose survived and the switch in the belly was recovered and found to have actuated. It is assumed that this switch fired the ARU-21 squib. There were no other release switches installed in the normally open system in the aircraft. R.J.F.

**N86-21946*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CONTROLLED IMPACT DEMONSTRATION ON-BOARD (INTERIOR) PHOTOGRAPHIC SYSTEM**

C. J. MAY *In its* Full-Scale Transport Controlled Impact Demonstration p 209-239 Jan. 1986 refs

Avail: NTIS HC A03/MF A01 CSCL 20K

Langley Research Center (LaRC) was responsible for the design, manufacture, and integration of all hardware required for the photographic system used to film the interior of the controlled impact demonstration (CID) B-720 aircraft during actual crash conditions. Four independent power supplies were constructed to operate the ten high-speed 16 mm cameras and twenty-four floodlights. An up-link command system, furnished by Ames Dryden Flight Research Facility (ADFRF), was necessary to activate the power supplies and start the cameras. These events were accomplished by initiation of relays located on each of the photo power pallets. The photographic system performed beyond expectations. All four power distribution pallets with their 20 year old Minuteman batteries performed flawlessly. All 24 lamps worked. All ten on-board high speed (400 fps) 16 mm cameras containing good resolution film data were recovered. R.J.F.

**N86-21947*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CID-720 AIRCRAFT HIGH-ENVIRONMENT FLIGHT INSTRUMENTATION SYSTEM**

R. S. CALLOWAY *In its* Full-Scale Transport Controlled Impact Demonstration p 241-287 Jan. 1986

Avail: NTIS HC A16/MF A01 CSCL 20K

The high-environment flight instrumentation system was designed to acquire Langley's structural response data during the full scale transport-controlled impact demonstration test. There was only one opportunity for data acquisition. Thus, a high reliability and crashworthy design approach was implemented. The approach featured multi-level redundancy and a vigorous quality assurance testing program. Complying with an accelerated schedule, the instrumentation system was developed, tested and shipped within 18 months to Dryden Flight Research Facility. The flight instrumentation system consists of two autonomous data systems, DAS #1 and #2, and an excellent checkout subsystem. Each data system is partitioned into four pallets. The system was designed to operate on manned and unmanned flights. There are 176 data channels per data system. These channels are sequentially sampled and encoded into 1 megabit/sec pulse code modulation (PCM) data signal. To increase the probability of success, a special PCM distribution subsystem was developed. This subsystem distributes the PCM signal to two transmitters, one delay memory, and eight recorder tracks. The data on four of these trackes was digitally delayed approximately 300 msec to maximize data acquisition during impact. Therefore each data system's data is redundantly recorded onboard and on the ground. There are two time code generators. Parallel time from each is encoded into both data systems. Serial time from each is redundantly recorded on both onboard recorders. Instrumentation power is independent of aircraft power and self-contained. R.J.F.

**N86-21948*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IMPACT DYNAMICS INSTRUMENTATION**

R. F. MCCORMCK *In its* Full-Scale Transport Controlled Impact Demonstration p 289-301 Jan. 1986

Avail: NTIS HC A16/MF A01 CSCL 20K

One of the tasks specified in the NASA Langley controlled impact demonstration (CID) work package was to furnish dynamic instrumentation sensors. The types of instrumentation sensors required were accelerometers for aircraft structural loads measurements, seat belt load cells to measure anthropomorphic dummy responses to the aircraft impact, and strain gage bending bridges to measure the aircraft fuselage and wing bending during impact. The objective in the selection of dynamic instrumentation for the CID was to provide 352 of the highest quality transducers and remain within budget allocation. The transducers that were selected for the CID evaluation process were each subjected to rigorous laboratory acceptance tests and to aircraft fuselage section drop tests at the LaRC Impact Dynamics Research Facility. Data compiled from this series of tests showed the selected transducers to be best suited for the CID mission requirement. The transducers installation technique on the airframe proved successful. The transducer quality assurance was guaranteed through rigorous acceptance testing. Data acquired was 97.0%. R.J.F.

**N86-21949*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CID-720 AIRCRAFT LANGLEY RESEARCH CENTER PREFLIGHT HARDWARE TESTS: DEVELOPMENT, FLIGHT ACCEPTANCE AND QUALIFICATION**

J. D. PRIDE *In its* Full-Scale Transport Controlled Impact Demonstration p 303-328 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 20K

The testing conducted on LaRC-developed hardware for the controlled impact demonstration transport aircraft is discussed. To properly develop flight qualified crash systems, two environments were considered: the aircraft flight environment with the focus on vibration and temperature effects, and the crash environment with the long pulse shock effects. Also with the large quantity of fuel in the wing tanks the possibility of fire was considered to be a threat to data retrieval and thus fire tests were included in the development test process. The aircraft test successfully demonstrated the performance of the LaRC developed heat shields. Good telemetered data (S-band) was received during the impact and slide-out phase, and even after the aircraft came to rest. The two onboard DAS tape recorders were protected from the intense fire and high quality tape data was recovered. The complete photographic system performed as planned throughout the 40.0 sec of film supply. The four photo power distribution pallets remained in good condition and all ten onboard 16 mm high speed (400 frames/sec) cameras produced good film data. R.J.F.

**N86-21954*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EQUIVALENT PLATE ANALYSIS OF AIRCRAFT WING BOX STRUCTURES WITH GENERAL PLANFORM GEOMETRY**

G. L. GILES Mar. 1986 12 p refs Proposed for presentation at the 27th AIAA/ASME/ASCE/ANS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986

(NASA-TM-87697; NAS 1.15:87697; AIAA-86-0940-CP) Avail: NTIS HC A02/MF A01 CSCL 20K

A new equivalent plate analysis formulation is described which is capable of modeling aircraft wing structures with a general planform such as cranked wing boxes. Multiple trapezoidal segments are used to represent such planforms. A Ritz solution technique is used in conjunction with global displacement functions which encompass all the seyements. This Ritz solution procedure is implemented efficiently into a computer program so that it can be used by rigorous optimization algorithms for application in early preliminary design. A *direct method* to interface this structural analysis procedure with aerodynamic programs for use in aeroelastic calculations is described. This equivalent plate analysis procedure is used to calculate the static deflections and stresses and vibration frequencies and modes of an example wing configuration. The numerical results are compared with results from a finite element model of the same configuration to illustrate typica levels of accuracy and computation times resulting from use o this procedure. Autho

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# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-29065*** National Aeronautics and Space Administration. National Space Technology Labs., Bay Saint Louis, Miss.
**CHARACTERIZATION OF SHALLOW OCEAN SEDIMENTS USING THE AIRBORNE ELECTROMAGNETIC METHOD**
I. J. WON (National Space Technology Laboratory, Bay St. Louis, MS; North Carolina State University, Raleigh) and K. SMITS (National Space Technology Laboratory, Bay St. Louis, MS) IEEE Journal of Oceanic Engineering (ISSN 0364-9059), vol. OE-11, Jan. 1986, p. 113-122. refs

Experimental airborne electromagnetic (AEM) survey data collected in Cape Cod Bay are used to derive continuous profiles of water depth, electrical depth, water conductivity, and bottom sediment conductivity. Through a few well-known empirical relationships, the conductivities are used, in turn, to derive density, porosity, sound speed, and acoustic reflectivity of the ocean bottom. A commercially available Dighem III AEM system was used for the survey without any significant modification. The helicopter-borne system operated at 385 and 7200 Hz; both were in a horizontal coplanar configuration. The interpreted profiles show good agreement with available ground truth data. Where no such data are available, the results appear to be very reasonable. Compared with the shipborne electrode array method, the AEM method can determine the necessary parameters at a much higher speed with a better lateral resolution over a wide range of water depths from 0 to perhaps 100 m. The bottom sediment conductivity that can be measured by the AEM method is closely related to physical properties of sediments, such as porosity, density, sound speed, and, indirectly, sediment types that might carry broad implications for various offshore activities. Author

**A86-28568#**
**A RING-VORTEX DOWNBURST MODEL FOR FLIGHT SIMULATIONS**
M. IVAN (Boeing Computer Services Co., Seattle, WA) (Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers, p. 57-61) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 232-236. Previously cited in issue 19, p. 2843, Accession no. A85-40561. refs

**A86-28618*** Hofstra Univ., Hempstead, N. Y.
**MEASUREMENTS OF OCEAN WAVE SPECTRA AND MODULATION TRANSFER FUNCTION WITH THE AIRBORNE TWO-FREQUENCY SCATTEROMETER**
D. E. WEISSMAN (Hofstra University, Hempstead, NY) and J. W. JOHNSON (NASA, Langley Research Center, Hampton, VA) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Feb. 15, 1986, p. 2450-2460. Previously announced in STAR as N84-27282. refs
(Contract NAGW-468)

The directional spectrum and the microwave modulation transfer function of ocean waves can be measured with the airborne two frequency scatterometer technique. Similar to tower based observations, the aircraft measurements of the Modulation Transfer Function (MTF) show that it is strongly affected by both wind speed and sea state. Also detected are small differences in the magnitudes of the MTF between downwind and upwind radar look directions, and variations with ocean wavenumber. The MTF inferred from the two frequency radar is larger than that measured using single frequency, wave orbital velocity techniques such as tower based radars or ROWS measurements from low altitude aircraft. Possible reasons for this are discussed. The ability to measure the ocean directional spectrum with the two frequency scatterometer, with supporting MTF data, is demonstrated. M.A.C.

**A86-29002**
**FORECASTING FOR CIVIL AVIATION. I**
L. DENT (Meteorological Office, Bracknell, England) Weather (ISSN 0043-1656), vol. 41, Feb. 1986, p. 42-48.

The development of forecasts for civil aviation is described. The International Civil Aviation Organization has developed a two-tiered system to provide airlines with the forecast information they require. The procedure involves utilizing global forecast models to forecast grid point data for upper winds and temperatures up to 45,000 ft. These data are supplied to regional forecast centers where wind and temperature charts with tropopause data are prepared; terminal airport forecasts are developed from these charts and applied to landings and take-offs and flight planning. The need to have current information available on surface wind on the runway, surface pressure, weather cloudbase and visibility, upper winds, and turbulence is examined. I.F.

**N86-20888#** Joint Publications Research Service, Arlington, Va.
**AN-30 PHOTOGRAPHY AIRPLANE OUTFITTED FOR CLOUD-SEEDING MISSIONS**
T. KUZNETSOVA and A. PIMENOV *In its* USSR Report: Earth Sciences (JPRS-UES-86-001) p 1-2 10 Jan. 1986 Transl. into ENGLISH from Pravda Ukrainy (Kiev, USSR), 15 Aug. 1985 p 4
Avail: NTIS HC A04

The development of the AN-30M airplane mode, which can modify the weather is discussed. It has excellent flight qualities, high reliability, and modern pilotage-and-navigation equipment that permits flight routes and course changes in the semiautomatic mode and takeoffs during daytime and nighttime, in difficult weather conditions. Ammunition against precipitation (crystalline and other reagents) is loaded into containers placed inside and outside the aircraft on external mounts with a streamlined shape. The instruments evaluate weather conditions outside the airplane and decide at what altitude the cloud cover should be seeded and on the methods to be used. The AN-30M seeds clouds with frozen carbon dioxide granules. The plane can induce additional rainfall on farmlands, increase snow cover, and extinguish forest fires. E.A.K.

**N86-21069*#** FWG Associates, Inc., Tullahoma, Tenn.
**ANALYSIS OF AERODYNAMIC COEFFICIENTS USING GRADIENT DATA: SPANWISE TURBULENCE EFFECTS ON AIRPLANE RESPONSE Report, 3 Jun. 1983 - 2 Jun. 1985**
E. A. RINGNES and W. FROST Washington NASA Feb. 1986 70 p refs
(Contract NAS8-35186)
(NASA-CR-3961; NAS 1.26:3961) Avail: NTIS HC A04/MF A01 CSCL 04B

The influence of spanwise turbulence on airplane dynamic behavior is determined. Calculations are based on data collected from test flights with the NASA B-57 research aircraft. The approach is to first compute aerodynamic forces and moments due to a spanwise distribution of angle of attack and airspeed. Secondly, these quantities are incorporated into the equations of motion. Simulation of flights done with the effects of spanwise turbulence included are compared to simulations without any spanwise turbulence. The findings of the study are that the moments developed by turbulence along the span are significant and that more realistic flight simulation can be achieved by including the spanwise turbulence terms. Author

**N86-21078#** Transportation Systems Center, Cambridge, Mass.
**THE STAPLETON MICROBURST ADVISORY SERVICE PROJECT: AN OPERATIONAL VIEWPOINT Final Report, Jun. 1984 - Sep. 1985**
L. STEVENSON Sep. 1985 80 p
(AD-A161543; DOT-TSC-FAA-85-8; DOT/FAA/PM-85/21) Avail: NTIS HC A05/MF A01 CSCL 04B

A microburst advisory service project was conducted at Stapleton International Airport for a six week period during the summer of 1984. This report describes what took place during the project and what was learned from an operational, air traffic control viewpoint. Specifically, the report describes: (1) The operational, Doppler weather radar-based, microburst advisory service provided to pilots; (2) An unplanned and informal, Doppler radar-based, gust front advisory service initiated partway through the project and used by the FAA for runway management purposes; (3) The operational impact on runway operations of an unexpected, low-altitude, wind shear feature in which individual microbursts form a relatively long-lived line structure; and (4) The low-altitude wind shear environment faced by Stapleton controllers and pilots during the six week project, which took place at the peak of the Denver thunderstorm season. A microburst is a small, short-lived, low-altitude, thunderstorm-related, wind shear feature that can exhibit an intense, complex wind shear pattern that can be particularly hazardous to landing and departing aircraft. GRA

**N86-21084#** Technische Hochschule, Aachen (West Germany). Dept. of Aerospace Engineering.
**WIND SHEAR MEASUREMENT ON BOARD A MORANE 893**
H. NELLES 1985 21 p refs
Avail: NTIS HC A02/MF A01

To investigate wind shear during flight, a pneumatic sensing device was developed and installed on board a single engine light aircraft. The device measures the difference in total pressure between two positions vertically displaced from the airplane. The mass flow rate created by the difference in pressure is measured by a hot-wire probe. The signal of this probe is a function of the wind shear. Results compare favorably with those of a ground based sensing system and a D028 research aircraft. Author (ESA)

**N86-21982*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**AIRBORNE TRACKING SUN PHOTOMETER APPARATUS AND SYSTEM Patent Application**
T. MATSUMOTO, C. MINA, P. RUSSELL, and W. VANARK, inventors (to NASA) 29 Jan. 1986 17 p
(NASA-CASE-ARC-11622-1; NAS 1.71:ARC-11622-1; US-PATENT-APPL-SN-823712) Avail: NTIS HC A02/MF A01 CSCL 10A

An airborne tracking Sun photometer apparatus has a rotatable dome. An aximuth drive motor is connected to rotate the dome. The dome has an equatorial slot. A cylinderical housing is pivotally mounted inside the dome at the equatorial slot. A photometer is mounted in the housing to move in the equatorial slot as the housing pivots. The photometer has an end facing outward from the slot with an optical flat transparent window. An elevation drive motor is connected to pivot the cylindrical housing. The rotatable dome is mounted in bulkhead of an aircraft to extend from the interior of the aircraft. A Sun sensor causes the photometer to track the Sun automatically. Alternatively, the photometer may be oriented manually (by voltages or by computer). NASA

**N86-22061#** Massachusetts Inst. of Tech., Lexington.
**WEATHER RADAR STUDIES Quarterly Technical Summary Report, 1 Jan. - 31 Mar. 1985**
J. E. EVANS 31 Mar. 1985 42 p
(Contract DT-FA01-80-Y-10546)
(AD-A161622; DOT/FAA/PM-85-16) Avail: NTIS HC A03/MF A01 CSCL 04B

FAA-funded Doppler weather radar activities during the period 1 January to 31 March 1985 are reported. The test-bed Doppler weather radar system measurements in Olive Branch, Mississippi, commenced following the installation of an improved lightning protection system. Clutter suppression testing showed that the objective of 50-dB suppression was obtained in the field against appropriate fixed targets. Weather measurements were conducted on a number of cold front passages with attendant prefrontal lines of showers and thunderstorms. The Lincoln mesonet was recalibrated at Lincoln in January and February and then installed at the site in late February. The mesonet was fully operational in March. The 1984 peak wind speed data from the mesonet and the Memphis International Airport LLWAS data were analyzed preliminarily to determine wind shear characteristics in the Memphis area. Doppler weather radar data from the National Center for Atmospheric Research JAWS program and the National Severe Storms Laboratory are being analyzed to develop low-altitude wind shear detection algorithms. GRA

**N86-22064#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abteilung Wolkenphysik.
**THE ICING RESEARCH AIRCRAFT DO28, D-IFMP OF DFVLR, AND ITS MEASURING EQUIPMENT**
H. E. HOFFMANN and J. DEMMEL Aug. 1985 72 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-972)
(DFVLR-MITT-85-12; ISSN-0176-7739) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 25.50

A Dornier Do28 D-IFMP, equipped as an icing research aircraft, is described. Ice accretion is measured on three metal cylinders and at the tip of one wing. The icing-relevant, cloud-physical parameters measured include air temperature, liquid water content, particle size (0.5 to 600 micron), particle concentration, particle phase (qualitative), visibility in and outside clouds, relative humidity, and absolute humidity. The measured data are recorded on two analog and one digital recorder. Author (ESA)

**N86-22067#** National Center for Atmospheric Research, Boulder, Colo.
**RELATIVE ACCURACY OF ALPEX AIRCRAFT DATA: AN EVALUATION OF THE ALPEX INTERCOMPARISON FLIGHT WITH THE NCAR (NATIONAL CENTER FOR ATMOSPHERIC RESEARCH) ELECTRA, THE NOAA (NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION P3 AND THE DFVLR (DEUTSCHE FORSCHUNGS- UND VERSUCHSANSTAIT FUER LUFT-UND RAUMFAHRT) FALCON**
H. RICHNER Jul. 1985 90 p
(PB86-100823; NCAR/TN-238+STR) Avail: NTIS HC A05/MF A01 CSCL 04B

During the ALPEX program, three participating large research aircraft--the NCAR Electra, the NOAA P3, and the DFVLR Falcon--joined for an intercomparison flight. Using the data from this flight, this report lists the relative accuracies for position, pressure, temperature, humidity, horizontal and vertical winds, radio altitude, and radiation (some of these quantities were measured by two aircraft only). The results are presented in form of basic statistical data such as mean differences, standard deviations, and correlation coefficients, as well as in form of power, coherence and--for some quantities--phase spectra. GRA

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# LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-28442**

**AUDITORY SIGNALS IN MILITARY AIRCRAFT - ERGONOMIC PRINCIPLES VERSUS PRACTICE**

T. J. DOLL and D. J. FOLDS (Georgia Institute of Technology, Atlanta) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 958-965. refs

(Contract F33615-82-D-0601)

The complete ensembles of auditory signals in selected USAF aircraft (the F-4D, F-15, two models of the F-16, the C-5, and the C-141) are described and evaluated. Human factors research related to the design of speech and non-speech auditory signals is reviewed. Major findings are: that auditory signals are not well standardized among the aircraft, even between those with similar combat roles; that a relatively large number of non-speech auditory signals are used, which may make it difficult for the aircrew to recall the meanings of all the signals; that some non-speech signals are sufficiently similar that they may be confused, particularly in high workload and stressful conditions; and that the criticality of the warnings is not reliably indicated by any characteristics of the signals. Four problem areas requiring further research are discussed: reduction of signal loudness, enhancement of the distinctiveness and masking resistance of non-speech signals, effects of concurrent warning signals on aircrew performance, and additional uses of auditory information. Author

**A86-28444**

**DYNAMIC RETRAINING APPROACHES FOR AN AIRBORNE SPEECH RECOGNITION SYSTEM**

R. A. NORTH and K. GRAFFUNDER (Honeywell Systems and Research Center, Minneapolis, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 970-974.

(Contract F33615-83-C-3608)

Results of a preliminary investigation of the viability of dynamic updating of a word recognizer are reported. An isolated word recognizer was used to capture original templates and task oriented utterances for an aircraft cockpit radio frequency selection task performed by a group of student pilots. The task-oriented utterances were produced in low and high workload conditions to represent differing operational stress. Match scores between original templates and real-time utterances were compared with match scores between real-time vs. real-time utterances. Two strategies were formulated for improvement of match scores using certain real-time utterances as new templates, and one is demonstrated with laboratory data. Author

**A86-28446*** Psycho-Linguistic Research Associates, Menlo Park, Calif.

**SELECTING COCKPIT FUNCTIONS FOR SPEECH I/O TECHNOLOGY**

C. A. SIMPSON (Psycho-Linguistic Research Associates, Menlo Park, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 979-986. Army-supported research. refs

(Contract NAS2-11341)

A general methodology for the initial selection of functions for speech generation and speech recognition technology is discussed. The SCR (Stimulus/Central-Processing/Response) compatibility model of Wickens et al. (1983) is examined, and its application is demonstrated for a particular cockpit display problem. Some limits of the applicability of that model are illustrated in the context of predicting overall pilot-aircraft system performance. A program of system performance measurement is recommended for the evaluation of candidate systems. It is suggested that no one measure of system performance can necessarily be depended upon to the exclusion of others. Systems response time, system accuracy, and pilot ratings are all important measures. Finally, these measures must be collected in the context of the total flight task environment. D.H.

**A86-28453**

**WICKENS' RESOURCE ALLOCATION MODEL - IMPLICATIONS FOR THE DESIGN OF HUMAN-MACHINE SYSTEMS**

L. A. WHITAKER (Missouri-St. Louis, University, St. Louis) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1040-1044. refs

A fundamental question of systems design is examined: can one person operate a given system or will it take two? The answer depends on the load that the system imposes on the operator. The model of Wickens, Sandry and Vidulich (1983) suggests that a single operator can draw from a number of separate internal resources to perform a complex task (such as fly an aircraft, provide air traffic control, or execute underwater maintenance tasks). If this model is correct, then systems can be designed to make optimal use of these separate resources within a single operator. The model is discussed and available evidence tending to support or refute it is examined. Implications for the design of air traffic control communications are noted. D.H.

**A86-28513**

**IMPROVING INTELLIGIBILITY IN AUDIO DISTRIBUTION SYSTEMS**

P. J. GRECO (Telephonics Corp., Huntington, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1564-1569. refs

Some of the most current techniques for increasing intelligibility in audio distribution systems operating in high ambient noise environments (engine noise, weapons launch, helicopter rotor slap, etc.) are examined. As part of a program to develop the new Tri-Service Digital Audio Distribution System (DADS), a systems approach has been taken to improving intelligibility. The solutions include better noise canceling microphones, active signal enhancement at the audio input, and both passive and active noise canceling devices as the headset. Initial data show that intelligibility scores of better than 75 percent in pink noise environments greater than 115 dB SPL have been achieved. D.H.

**A86-28864*** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EVALUATION OF 16 MEASURES OF MENTAL WORKLOAD USING A SIMULATED FLIGHT TASK EMPHASIZING MEDIATIONAL ACTIVITY**

W. W. WIERWILLE, M. RAHIMI, and J. G. CASALI (Virginia Polytechnic Institute and State University, Blacksburg) Human Factors (ISSN 0018-7208), vol. 27, Oct. 1985, p. 489-502. Research supported by the Virginia Polytechnic Institute and State University. refs

(Contract NAG2-17)

As aircraft and other systems become more automated, a shift is occurring in human operator participation in these systems. This shift is away from manual control and toward activities that tap the higher mental functioning of human operators. Therefore, an experiment was performed in a moving-base flight simulator to assess mediational (cognitive) workload measurement. Specifically, 16 workload estimation techniques were evaluated as to their sensitivity and intrusion in a flight task emphasizing mediational behavior. Task loading, using navigation problems presented on a display, was treated as an independent variable, and workload-measure values were treated as dependent variables. Results indicate that two mediational task measures, two rating scale measures, time estimation, and two eye behavior measures were reliably sensitive to mediational loading. The time estimation measure did, however, intrude on mediational task performance. Several of the remaining measures were completely insensitive to mediational load. Author

**A86-29092**

**HEAD-UP/HEAD-DOWN TRANSITION - MEASUREMENT OF TRANSITION TIMES**

J.-P. R. MENU (Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris, France) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, March 1986, p. 218-222. DRET-supported research. refs

A method to measure transition times between a head-up display (HUD) signal and a response given to a head-down display (HDD) was developed, using a three-segmented paradigm and testing various vocal and manual arrangements in a fighter aircraft mock-up. The shortest transition times were obtained for voice responses (1600 msec between a HUD signal and a simple response to the HDD). A comparison of the perception and transition times of a 'positive' contrast (green symbols on black background) with a 'negative' contrast (black symbols on green) has indicated both shorter perception and shorter transition times for the positive contrast. This method permits of the effects evaluation of changes in psychological conditions (such as heavier information processing) and physiological conditions (changing accommodation, gaze axis, and convergence) of a dynamic aeronautical environment on the speeds of acquisition and processing of information. I.S.

**A86-29100**

**SHIP/RIG PERSONNEL ABANDONMENT AND HELICOPTER CREW/PASSENGER IMMERSION SUITS - THE REQUIREMENTS IN THE NORTH ATLANTIC**

C. J. BROOKS (Department of National Defence, Maritime Command, Halifax, Canada) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, March 1986, p. 276-282. refs

**N86-22110#** Army Construction Engineering Research Lab., Champaign, Ill.

**THE ROLE OF VIBRATION AND RATTLE IN HUMAN RESPONSE TO HELICOPTER NOISE Final Report**

P. D. SCHOMER and R. D. NEATHAMMER Sep. 1985 161 p
(AD-A162486; CERL-TR-N-85/14) Avail: NTIS HC A08/MF A01 CSCL 05J

Our understanding of community reaction to helicopter noise remains incomplete. A technique called A-weighting appears to produce realistic data outdoors and at modest noise levels, and the community response in terms of percentage of population highly annoyed can be correlated with respect to the Day/Night Average Sound Level (DNL) descriptor. However, questions remain as to the effect of perceived building vibrations and rattle in human response to helicopter noise. To answer these questions, this study examined the role of vibration and rattle in human response to helicopter noise. Many volunteer subjects were tested under real noise conditions. The helicopter noise was generated by an Army UH-1H (Huey) helicopter. Subjects were located either in the living room of a new mobile home, outdoors, or in the living room or dining room of an old frame farmhouse near Champaign IL. The control or comparison sound was generated electronically through loudspeakers at each location using a 500-Hz octave band of white noise. By performing paired comparison tests between the helicopter and control noises, it was possible to establish equivalency between these two stimuli. Author (GRA)

**N86-22113*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**DIRECT MODEL REFERENCE ADAPTIVE CONTROL OF A FLEXIBLE ROBOTIC MANIPULATOR**

D. R. MELDRUM 15 Dec. 1985 90 p refs
(Contract NAS7-918)
(NASA-CR-176659; JPL-PUB-85-100; NAS 1.26:176659) Avail: NTIS HC A05/MF A01 CSCL 05H

Quick, precise control of a flexible manipulator in a space environment is essential for future Space Station repair and satellite servicing. Numerous control algorithms have proven successful in controlling rigid manipulators with colocated sensors and actuators; however, few have been tested on a flexible manipulator with noncolocated sensors and actuators. In this thesis, a model reference adaptive control (MRAC) scheme based on command generator tracker theory is designed for a flexible manipulator. Quicker, more precise tracking results are expected over nonadaptive control laws for this MRAC approach. Equations of motion in modal coordinates are derived for a single-link, flexible manipulator with an actuator at the pinned-end and a sensor at the free end. An MRAC is designed with the objective of controlling the torquing actuator so that the tip position follows a trajectory that is prescribed by the reference model. An appealing feature of this direct MRAC law is that it allows the reference model to have fewer states than the plant itself. Direct adaptive control also adjusts the controller parameters directly with knowledge of only the plant output and input signals. Author

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## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-26577**

**NUMERICAL FIXED-POINT SOLUTION FOR NEAR-OPTIMUM REGULATORS OF LINEAR QUADRATIC GAUSSIAN CONTROL PROBLEMS FOR SINGULARLY PERTURBED SYSTEMS**

Z. GAJIC (Rutgers University, Piscataway, NJ) International Journal of Control (ISSN 0020-7179), vol. 43, Feb. 1986, p. 373-387. refs
(Contract NSF ECF-82-05337)

The fixed-point method is developed for obtaining an efficient numerical solution of the linear quadratic Gaussian problem for singularly perturbed systems. It is shown that each iteration step improves the accuracy by an order of magnitude, that is, the accuracy O(epsilon-k) can be obtained by performing only k - 1 iterations. In addition, only low-order systems are involved in algebraic manipulations and no analyticity requirements are imposed on the system coefficients. Author

**A86-27472**

**APPLICATION OF FUZZY LOGIC TO THE ESTIMATION OF SOFTWARE RELIABILITY FOR COMPUTER SYSTEMS [PRIMENENIE NECHETKOI LOGIKI DLIA OTSENKI NADEZHNOSTI PROGRAMMNOGO OBESPECHENIIA VYCHISLITEL'NYKH SISTEM]**

IU. N. MINAEV (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) Elektronnoe Modelirovanie (ISSN 0204-3572), vol. 8, Jan.-Feb. 1986, p. 52-56. In Russian. refs

Various aspects of the synthesis of algorithms for the estimation of software reliability in computer systems are examined. Fuzzy logic (specifically fuzzy deductibility schemes) is suggested as the basis for the algorithms. Models for the operation of computer systems when a failure state appears are considered. The operation of the Censor-932 computer system (part of an air traffic control system) is considered as an example. B.J.

**A86-28280**

**MODELING AND SIMULATION. VOLUME 15 - PROCEEDINGS OF THE FIFTEENTH ANNUAL PITTSBURGH CONFERENCE, UNIVERSITY OF PITTSBURGH, PA, APRIL 19, 20, 1984. PART 5 - GENERAL MODELING AND SIMULATION**

W. G. VOGT, ED. and M. H. MICKLE, ED. Research Triangle Park, NC, Instrument Society of America, 1984, 317 p. No individual items are abstracted in this volume.

Consideration is given to the general modeling and simulation problems which were addressed at the Fifteenth Annual Pittsburgh Conference on Modeling and Simulation. Among the specific problems discussed are: air-traffic control simulation; the influence of sampling rate on a pilot's assessment of the handling characteristics of a simulated aircraft; and the application of job simulation in evaluating alternative layout plans. Consideration is also given to: modeling of real systems; analysis of cracking reactions in structures; polymerization simulations; and modeling of a flight operations manual for the International Ultraviolet Explorer (IUE) spacecraft. Additional topics discussed include: analog simulation of Josephson effects; simulation and optimization models for integrated production planning; and hierarchical multilevel interactive systems simulators. Author

**A86-28307**

**CONTROL OF THE FLIGHT TESTING OF AIRCRAFT AS A MEANS OF INCREASING THEIR RELIABILITY [UPRAVLENIE LETNYMI ISPYTANIIAMI LETATEL'NYKH APPARATOV KAK SREDSTVO POVYSHENIIA IKH NADEZHNOSTI]**

V. S. PUGACHEV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 25-38. In Russian. refs

The problem of flight test optimization is reduced to an analysis of stochastic differential equations, and methods for estimating the parameters and variables of these equations are proposed. The same approach is also proposed for estimating the variables and parameters of discrete systems in the case where difference equations are used. V.L.

**A86-28348#**

**DATA-DRIVEN OPERATING CONCEPTS FOR REAL-TIME SIMULATION SYSTEMS**

R. A. WALLACE, D. O. HAGUE, and J. E. MCDONALD (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 156-163.

Distributed computer architectures are widely applied to the design of real-time simulation systems for military use. The paper discusses one such architecture. It is for employment in modular and computationally expendable flight simulators and embedded computer system integration support facilities. The architecture is designed to combine and replace shared memory systems and packet switched networks for real-time use. The advantages and implementation of the combination is normally obscure. Shared memory systems are easy to program but limited in network utility. Packet switched networks are easy to configure but difficult to efficiently manage for an intensive real-time environment. Laboratory designs and simple experimental tests illustrate the details and the utility of the new architecture. Author

**A86-28368**

**STATE ESTIMATION ERRORS IN DIGITAL KALMAN FILTERS CAUSED BY MEASUREMENT DELAYS AND NUMERICAL INTEGRATION**

E. J. BAUMAN and C. E. FOSHA (Colorado, University, Colorado Springs) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 336-342.
(Contract F33615-84-K-3602)

Continuing analysis of state estimator errors in director weapon control systems has led to isolating several error sources. Numerically integrated measurements, data delays and data pre-filtering all cause Kalman filter state estimation errors. A simple tracking scenario shows tutorially both analytically and by simulation that these errors can be very significant. The analysis shows that these errors can be reduced by reducing the sampling period, increasing the order of the numerical integrator and/or appropriately delaying or filtering other measurements. Author

**A86-28380**

**REAL TIME OPTIMAL FLIGHT PATH GENERATION BY STORAGE OF MASSIVE DATA BASES**

Y. K. CHAN and M. FODDY (Boeing Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 516-521.

Dynamic programming is traditionally considered too time consuming for real time applications in a fine scale. The storage of a massive precomputed data base of intermediate results in the dynamic programming process is proposed. The numerical processing in real time is then reduced to a manageable updating of this data base to account for new information in the vicinity of the airplane. Thus the full benefit of the optimization by dynamic programming can be realized even in a real time environment. Author

**A86-28403**

**A MODELING STRUCTURE FOR COMPUTER AIDED DESIGN**

C. A. HARVEY, D. P. JOHNSON, D. J. LOWRY, and T. D. PIERCE (Honeywell Systems and Research Center, Minneapolis, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 642-646.

A structure is described for the representation of analytical design models of aircraft. This structure is motivated by the desire for automated data transmittal of a model that may be used by all design groups. Such a structure could lead to model standardization and better interdisciplinary communication. An illustrative example is also described to demonstrate some of the features in a specific environment. The example vehicle is the B-1A, and the model was used for the design of integrated flight control commands for terrain following/terrain avoidance using multivariable control technology. The dynamics of the engine and flexible aircraft with unsteady aerodynamics are included in the model. For this example, the modeling software is based on Honeyx routines and the UNIX operating system, but the general structure described should be appropriate for other operating systems and software packages. Author

**A86-28413**

**AVOIDING PROBE TO MODEL COLLISIONS IN WIND TUNNEL TESTING**

G. W. WILLIAMS, JR. (USAF, Wright-Patterson AFB, OH) and K. K. GOROWARA (Wright State University, Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 720-727. refs

A set of programs has been developed whose ultimate function is to detect potential collisions between a moving probe and a movable model in the finite work space of a wind tunnel test section. This task is accomplished in a two step process. The first step incorporates an interactive 'three-dimensional object' editor, and the second step performs axis transformations and collision detection in real time. An object is defined by a set of faces, edges, and vertices. The collision detection routines transform the probe survey stations, probe 'three-dimensional object' and the model 'three-dimensional object' to world coordinates. The collision detection routines can then analytically determine if two objects in the work space have intersected by testing edges of one object for intersection with a face of another object. If no potential collision is found, the probe drive system is then allowed to move the probe. Author

**A86-28419**

### A NEW APPROACH TO ENSURING DETERMINISTIC PROCESSING IN AN INTEGRATED AVIONICS SOFTWARE SYSTEM

J. R. ELLIS (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 756-763.

A software architecture providing mechanisms for highly reliable avionics systems which must integrate a variety of task execution rates and criticalities is presented. The executive supports single and multiprocessor systems for both cyclic and event driven tasks; foreground and background tasking with task suspension are implemented. Also covered are built-in-test features which ensure reliability. The architecture supports the use of high-level programming languages and is compatible with such advanced language features as 'tasking' and 'rendezvous' as defined for Ada. The architecture described here has been implemented in an integrated avionics software system for the Agusta A-129 Light Attack Helicopter. V.L.

**A86-28420**

### DESIGNING INTO THE UNKNOWN

M. HACKMAN (Boeing Military Airplane Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 764-769.

The concept of 'configurable software', i.e., software generically constructed and table-driven to suit special contexts from tables read in at program initialization, is examined. Such an approach makes it possible to bypass many of the rigidities created by attempting to design from top down and many of the uncertainties involved in designing from bottom up. General guidelines for developing configurable software are discussed with reference to an effort to design track-file software to form the core of a battle-management system intended for the next generation of tactical fighters. V.L.

**A86-28421**

### A FORTRAN ALGORITHM FOR TERRAIN PERSPECTIVE AND PLAN VIEW DISPLAY

B. RICHARDSON and W. LIM (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 770-775.

A FORTRAN algorithm has been developed which will generate a three-dimensional perspective terrain display and a two-dimensional plan view. Each of these displays are generated from a patch of terrain which is stored in digital format. This paper describes the algorithm, its memory and computational requirements as well as its development and potential utilization. Author

**A86-28430**

### IV&V FOR THE AUTOMATIC TEST CONTROL SYSTEM IN THE USAF AEROPROPULSION SYSTEMS TEST FACILITY

R. M. VINING (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) and W. ALBANES (Associated Technology Co., Estill Springs, TN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 843-850.

This paper documents Independent Verification and Validation (IV&V) methods and tools used during development of an Automatic Test Control System for the Aeropropulsion Systems Test Facility at the USAF Arnold Engineering Development Center, Arnold AFS, TN. The V&V effort was applied to the control algorithms, the computer system hardware, and the interface support equipment. Author

**A86-28456#**

### A CASE STUDY IN SIMULATION VS. STIMULATION - THE B-1 WEAPON SYSTEM TRAINER

M. H. TAINT (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1062-1067.

A topic of controversy in the training technology area is discussed, namely the relative merits of functional simulation (software modeling) as opposed to stimulation (using aircraft processors and software) to simulate avionics processors and their associated software. A case study in the 'stim vs. sim' debate is examined by comparing the design approaches to simulating the offensive and defensive avionics processors on the original B-1 (the B-1A) and B-1B weapon system trainers. For the B-1A, both stations were to be functionally simulated, while the B-1B approach is a mixture of functional simulation of the defensive station with stimulation of the offensive station. Alternate approaches to avionics processor/software simulation is also discussed. D.H.

**A86-28483#**

### DATA SYSTEMS FOR LOGISTICS EVALUATION DURING OPERATIONAL TEST

J. R. FINCH and W. T. MAULDIN (USAF, Operational Test and Evaluation Center, Kirtland AFB, NM) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1286-1288.

Data collection and processing systems used by the Operational Test Center to support its suitability evaluations are addressed. The Center uses the System Effectiveness Data System (SEDS) adn OMNIVORE (which accepts data from standard Air Force data collection systems) to support its evaluations of aircraft, munitions, and command, control and communications systems. These two systems are flexible and user-oriented and provide the data necessary to assess system reliability, maintainability, and availability. Additionally, Test Center personnel have developed microcomputer tools to assist in data projection and analysis. Efforts are under way to expand the capability for remote data input and analysis via microcomputer, to develop data systems appropriate to space systems, and to estimate the maturity of system software. D.H.

**A86-28486**

### EXPERT SYSTEMS FOR REAL TIME APPLICATIONS

J. K. CLEMA (IIT Research Institute, Annapolis, MD), R. WERLING (Technion International, Wilmington, DE), and A. CHANDE (Systems and Applied Sciences Corp., Vienna, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1322-1329. refs

The problems of using and building on the methodology emmployed in today's 'expert systems' in a real-time laboratory-environment approach to demonstrate machine learning are discussed. Artificial intelligence and cognitive techniques applicable to dynamic, real-time, rapidly changing combat situations are examined. Expert systems which use modeling and simulation systems (such an AVSAIL models), off-the-shelf operations research tools, fuzzy logic, control theory, and decision theoretics are recommended as the approach DARPA should use in attaining the Pilot's Associate System goal of employing emerging machine intelligence technology to assist the combat pilot in advanced aircraft in the 1995 time period. A model of a dynamic, real-time, adaptive expert system is provided. D.H.

**A86-28407**

**EXPERT SYSTEM APPLICATIONS TO THE COCKPIT OF THE '90S**

K. FRANKOVICH (USAF, Washington, DC), K. PEDERSEN, and S. BERNSTEEN IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1330-1335.

The requirements, enabling technologies, and potential structure of the next generation of avionics - employing expert systems - are addressed. Two examples of the potential of future avionics expert systems are considered: a navigation and route planning expert and a threat assessment and threat reaction expert. D.H.

**N86-21168#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

**PARAMETRIC BI-CUBIC SURFACE PATCH FOR COMPUTER AIDED GEOMETRIC DESIGN OF AIRCRAFT AND/OR OTHER THREE-DIMENSIONAL GEOMETRIES**

H. N. V. DUTT Sep. 1985 58 p refs

(NAL-TM-AE-8505) Avail: NTIS HC A04/MF A01

A FORTRAN program was developed to fit smooth surfaces to the component parts of an arbitrary aircraft configuration or any three dimensional geometry. The basic surface element used for this fit is a bicubic surface patch. Once the geometry was replaced by a set of patch equations, various kinds of calculations which require a three dimensional mathematical description of the surface can be performed easily. The second part of the code generates orthographic views of the given geometry on a calcomp drum plotter or on a Tektronix screen. The last part of the program generates cross sectional plots at any desired orientation through the given configuration. Also this module can be used to generate cross sectional areas, intermediate sections and other geometric details of the given configuration. The input data is oriented mainly towards aircraft geometry. But the code can be efficiently used for representing any arbitrary surface or a combination of both. Author

**N86-21219#** National Aerospace Lab., Tokyo (Japan).

**COVARIANCE SPECIFICATION FOR THE LINEAR TIME-INVARIANT OUTPUT-FEEDBACK CONTROL SYSTEMS USING A KALMAN FILTER**

M. NAGAYASU Oct. 1985 16 p refs In JAPANESE; ENGLISH summary

(NAL-TR-882; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The covariance specification problem using a Kalman filter for the linear time-invariant output-feedback control system contaminated by observation and system noise is described. Linear stochastic control problems based on the quadratic performance criteria were studied. However, the relationships between the criteria and the behavior of the resultant closed loop system are still in question today. The optimal output-feedback control using a Kalman filter with which the stationary state covariance matrix coincides with the prescribed matrix is described. The system is disturbed by additive white/color system noise and the output signal is contaminated by white observation noise. The dynamic output feedback control system is obtained by using a Kalman filter. The covariance specification problem, i.e., to obtain the optimal feedback gains under the requirement of the state covariance coinciding with the prescribed covariance for minimizing the control effort, is solved. The control problem of an aircraft in atmospheric turbulence is numerically discussed. E.A.K.

**N86-21232#** National Aeronautical Lab., Bangalore (India). Systems Engineering Div.

**COMPUTATION OF TRANSFER FUNCTION MATRICES**

J. K. SRIDHAR and B. SATYABHAGAVAN Aug. 1985 30 p refs

(NAL-TM-SE-8509) Avail: NTIS HC A03/MF A01

Control systems design in frequency domain involves the computation of transfer function matrices. Details of the software developed on UNIVAC-1100/60 to compute transfer function matrices and hence zeros and poles of numerator and denominator polynomials respectively are given. The software developed here is intended to form an integral part of a package available in the division to study longitudinal and lateral dynamics of an aircraft. Numerical algorithm and schematic flow chart is presented along with an example on a fighter aircraft model. The software is documented and validated. A user manual is provided. Author

**N86-21233#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

**A PRELIMINARY NOTE ON THE DEVELOPMENT OF A THREE DIMENSIONAL POTENTIAL CODE IN CARTESIAN COORDINATES**

S. S. DESAI, R. RANGARAJAN, and K. S. RAVICHANDRAN Jul. 1985 53 p refs

(NAL-TM-AE-8504) Avail: NTIS HC A04/MF A01

An existing two dimensional transonic code TRADE1 was extended in Cartesian coordinates to three dimensions. A code was developed using Cartesian coordinates, instead of the more involved body fitting coordinates, so that the incorporation of a fuselage in the code developed for wing alone case becomes straight forward. The preliminary studies show encouraging results, but also bring into focus areas in a flow field where more needs to be done for a good resolution of the flow details, particularly for swept, tapered wings. Author

**N86-21260#** Lawrence Livermore National Lab., Calif.

**APPLICATION OF PRA TO HEMP VULNERABILITY ANALYSIS**

R. W. MENSING Sep. 1985 57 p

(Contract W-7405-ENG-48)

(DE86-001781; UCID-20553) Avail: NTIS HC A04/MF A01

Vulnerability analyses of large systems, e.g., control and communication centers, aircraft, ships, are subject to many uncertainties. A basic source of uncertainty is the random variation inherent in the physical world. Thus, vulnerability is appropriately described by an estimate of the probability of survival (or failure). The estimate of the probability of survival is not a single value but a range of values. Probabilistic risk analysis (PRA) is a methodology which deals with these uncertainty issues. This report discusses the application of PRA to HEMP vulnerability analyses. Vulnerability analysis and PRA are briefly outlined and the need to distinguish between random variation and modeling uncertainty is discussed. Then a sequence of steps appropriate for applying PRA to vulnerability problems is outlined. Finally, methods for handling modeling uncertainty are identified and discussed. DOE

**N86-21938*#** Space Development Corp., Hampton, Va.

**DATA REDUCTION, MANAGEMENT, AND ANALYSIS SOFTWARE FOR CID**

C. W. DAVIS *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 61-77 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 20K

In an overview of the Data Reduction System, three major steps are examined. First, the raw data tapes were selected from the onboard recorders. These tapes should provide the best quality data for the data reduction software system. These tapes contained 352 channels of data, plus the monitor channels recorded in 8 bit Pulsed Coded Modulation (PCM) words. The next step consists of transcribing the PCM tapes from 8 bit serial digital data to 8 bit parallel digital data. This puts the data in the correct format for processing. The transcription process was accomplished here at LaRC in the Central Data Transportation Facility (CDTF). The last step in this 3 step process is to process the data through the reduction system developed for the Impact Dynamic Research Facility in the early part of 1980. Processing system criteria, system interface routines, and engineering units program that reads digitized data from tapes, and file management programs are discussed. R.J.F.

**N86-21941*#** PRC Kentron, Inc., Hampton, Va.

**DIGITAL FILTERING AND ACCELERATION PULSE INTERPRETATION**

E. L. PASANELLA *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 103-123 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 12A

It was concluded that the post processing digital filter is quite effective for removing unwanted high frequency and noise without distorting the signal. In addition, digital filtering is effective for smoothing low-level low resolution digital data where the digital stairstep phenomena are pronounced. Integrating the acceleration data to obtain velocity traces is quite useful. The velocity change provides a check on the validity of the acceleration trace. (Zero offsets in acceleration must be removed before integrating.) Average accelerations can be obtained from the velocity trace by dividing the change in velocity for an acceleration pulse by the pulse duration. One can obtain the peak of an equivalent triangular pulse by doubling the average acceleration. Author

**N86-22159#** Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).

**SELECTION OF A MAN-MODELLING CAD (COMPUTER-AIDED DESIGN)**

P. L. ROTHWELL Sep. 1985 22 p

(AD-A161342; DCIEM-85-C-36) Avail: NTIS HC A02/MF A01 CSCL 09B

DCEIM has been tasked to review Canadian Forces (CF) aircrew/cockpit compatibility and to make recommendations regarding future aircrew selection standards. Computer man-modelling has been proposed as the method to address the evaluation. In this report, three potential computer-aided design, man-modelling programs (CAR, COMBIMAN and SAMMIE) are evaluated. The ELECTRE multi-criteria decision making process was used to select the most appropriate program. The criteria were based on man-modelling and workspace-modelling features, and the capabilities to address the problems of reach, clearance and vision in aircraft crew stations. The results of the analysis support the recommendation to procure SAMMIE. SAMMIE was also found to be suitable to other work station design applications. GRA

**N86-22208#** Harvard Univ., Cambridge, Mass. Center for Research in Computer Technology.

**MOTION PLANNING IN THE PRESENCE OF MOVING OBSTACLES**

J. H. REIF and M. SHARIR 1985 30 p

(Contract N00014-80-C-0647)

(AD-A161374; TR-06-85) Avail: NTIS HC A03/MF A01 CSCL 12A

This paper investigates the computational complexity of planning the motion of a body B in 2-D or 3-D space, so as to avoid collision with moving obstacles of known, easily computed, trajectories. Dynamic movement problems are of fundamental importance to robotics, but their computational complexity has not previously been investigated. We provide evidence that the 3-D dynamic movement problem is intractable even if B has only a constant number of degrees of freedom of movement. In particular, we prove the problem is PSPACE-hard if B is given a velocity modulus bound on its movements and is NP hard even if B has no velocity modulus bound, where in both cases B has 6 degrees of freedom. To prove these results we use a unique method of simulation of a Turing machine which uses time to encode configurations (whereas previous lower bound proofs in robotics used the system position to encode configurations and so required unbounded number of degrees of freedom). We also investigate a natural class of dynamic problems which we call asteroid avoidance problems: B, the object we wish to move, is a convex polyhedron which is free to move by translation with bounded velocity modulus and the polyhedral obstacles have known translational trajectories but cannot rotate. This problem has many applications to robot, automobile, and aircraft collision avoidance. GRA

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# PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-26888*#** Missouri Univ., Rolla.

**APPLICATION OF THE FINITE ELEMENT METHOD IN THE CALCULATION OF TRANSMISSION LOSS OF FLAT AND CURVED PANELS**

L. R. KOVAL, S. MOTAMEDI, and J. V. RAMAKRISHNAN (Missouri-Rolla, University, Rolla) IN: Fluid-structure interaction and aerodynamics damping; Proceedings of the Tenth Biennial Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 10-13, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 19-28. refs

(Contract NAG1-240)

This investigation represents an extension of a study of Roussos (1985) who considered the noise transmission loss of a rectangular plate in an infinite baffle. Roussos, who employed an analytical formulation, considered an unstiffened plate. While it is difficult to consider stiffeners by means of analytical methods, the difficulties can be avoided by employing a finite element procedure. For this reason, the present study is concerned with the implementation of a finite element method. The representation of the panel transmission loss is discussed, and the determination of the panel motion by means of the finite element technique is described, taking into account an isotropic flat panel, the exciting force, an eigenvalue problem, the radiation pressure, a plate element, and a cylindrical shell element. Numerical results are considered for a flat panel, a curved panel, and a stiffened flat panel. G.R.

**A86-27658*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HELICOPTER MODEL ROTOR-BLADE VORTEX INTERACTION IMPULSIVE NOISE - SCALABILITY AND PARAMETRIC VARIATIONS**

D. A. BOXWELL, F. H. SCHMITZ (NASA, Ames Research Center, U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), W. R. SPLETTSTOESSER, and K. J. SCHULTZ (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 19 p. Previously announced in STAR as N85-16826. refs

Acoustic data taken in the anechoic Deutsch-Niederlaendischer Windkanal (DNW) have documented the blade vortex interaction (BVI) impulsive noise radiated from a 1/7-scale model main rotor of the AH-1 series helicopter. Averaged model scale data were compared with averaged full scale, inflight acoustic data under similar nondimensional test conditions. At low advance ratios (mu = 0.164 to 0.194), the data scale remarkable well in level and waveform shape, and also duplicate the directivity pattern of BVI impulsive noise. At moderate advance ratios (mu = 0.224 to 0.270), the scalig deteriorates, suggesting that the model scale rotor is not adequately simulating the full scale BVI noise; presently, no proved explanation of this discrepancy exists. Carefully performed parametric variations over a complete matrix of testing conditions have shown that all of the four governing nondimensional parameters - tip Mach number at hover, advance ratio, local inflow ratio, and thrust coefficient - are highly sensitive to BVI noise radiation. Author

**N86-21279#** Federal Aviation Administration, Washington, D.C.
**NOISE LEVELS FOR US CERTIFICATED AND FOREIGN AIRCRAFT**
4 Nov. 1985 101 p
(FAA-AC-36-1D) Avail: NTIS HC A06/MF A01

U.S. Department of Transportation Advisory Circular No. 36-1D (11/4/85) provides noise level data for airplanes certificated under FAR Part 36. Noise level data for foreign airplanes certificated to ICAO Annex 16 standards are also provided in a separate appendix for informational purposes. New appendices have been added to represent selected configurations of U.S. certificated aircraft and to provide listings of noise levels ranked in descending order. Author

**N86-21280*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**NEW TECHNIQUES FOR EXPERIMENTAL GENERATION OF TWO-DIMENSIONAL BLADE-VORTEX INTERACTION AT LOW REYNOLDS NUMBERS**
E. BOOTH, JR. and J. C. YU Mar. 1986 27 p refs
(NASA-TP-2551; L-15981; NAS 1.60:2551) Avail: NTIS HC A03/MF A01 CSCL 20A

An experimental investigation of two dimensional blade vortex interaction was held at NASA Langley Research Center. The first phase was a flow visualization study to document the approach process of a two dimensional vortex as it encountered a loaded blade model. To accomplish the flow visualization study, a method for generating two dimensional vortex filaments was required. The numerical study used to define a new vortex generation process and the use of this process in the flow visualization study were documented. Additionally, photographic techniques and data analysis methods used in the flow visualization study are examined. Author

**N86-21287#** Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.
**RECENT EXPERIENCES IN THE ANALYSIS OF AIRCRAFT CABIN NOISE**
R. F. C. KRIENS 1985 5 p refs Presented at Inter-Noise 85, Munich, West Germany, 18-20 Sep. 1985
Avail: NTIS HC A02/MF A01

Reduction of cabin noise in propeller driven aircraft is discussed. Separation of cabin noise into left and right hand components is described. Acoustic finite element analysis and airborne acoustic intensity measurements are reviewed. Author (ESA)

**N86-22302** National Physical Lab., Teddington (England). Div. of Radiation Science and Acoustics.
**AN EXPERIMENTAL APPRAISAL OF THE USE OF GROUND-PLANE MICROPHONES FOR AIRCRAFT NOISE MEASUREMENT**
R. C. PAYNE Aug. 1985 50 p refs
(NPL-AC-104; ISSN-0143-7143) Avail: Issuing Activity

Sound pressure levels measured using ground-plane microphone configurations are compared with pressure-doubled spectra derived from measurements using a conventional 1.2 m microphone location. Experimental data were obtained under laboratory conditions and in the field using a stationary sound source producing pure tone signals or shaped white noise. An arrangement involving a half-inch condenser microphone inverted over a circular baffle gives a close approximation to a pressure-doubled spectrum. Field trials using over-flights of light propeller-driven aircraft confirm the validity of the arrangement. Author (ESA)

**N86-22304*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AIRPORT-NOISE LEVELS AND ANNOYANCE MODEL (ALAMO) USER'S GUIDE**
R. DELOACH, J. L. DONALDSON, and M. J. JOHNSON Jan. 1986 129 p Prepared in cooperation with Computer Sciences Corp., Hampton, Va.
(NASA-TM-87695; NAS 1.15:87695) Avail: NTIS HC A07/MF A01 CSCL 20A

A guide for the use of the Airport-Noise Level and Annoyance MOdel (ALAMO) at the Langley Research Center computer complex is provided. This document is divided into 5 primary sections, the introduction, the purpose of the model, and an in-depth description of the following subsystems: baseline, noise reduction simulation and track analysis. For each subsystem, the user is provided with a description of architecture, an explanation of subsystem use, sample results, and a case runner's check list. It is assumed that the user is familiar with the operations at the Langley Research Center (LaRC) computer complex, the Network Operating System (NOS 1.4) and CYBER Control Language. Incorporated within the ALAMO model is a census database system called SITE II. Author

**N86-22305*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AIRPORT-NOISE LEVELS AND ANNOYANCE MODEL (ALAMO) SYSTEM'S REFERENCE MANUAL**
R. DELOACH, J. L. DONALDSON, and M. J. JOHNSON Jan. 1986 129 p refs Prepared in cooperation with Computer Sciences Corp., Hampton, Va.
(NASA-TM-87694; NAS 1.15:87694) Avail: NTIS HC A06/MF A01 CSCL 20A

The airport-noise levels and annoyance model (ALAMO) is described in terms of the constituent modules, the execution of ALAMO procedure files, necessary for system execution, and the source code documentation associated with code development at Langley Research Center. The modules constituting ALAMO are presented both in flow graph form, and through a description of the subroutines and functions that comprise them. Author

**N86-22306*#** Bionetics Corp., Hampton, Va.
**AN EVALUATION OF STUDY DESIGN FOR ESTIMATING A TIME-OF-DAY NOISE WEIGHTING**
J. M. FIELDS Mar. 1986 30 p refs
(Contract NAS1-16978)
(NASA-CR-178062; NAS 1.26:178062) Avail: NTIS HC A03/MF A01 CSCL 20A

The relative importance of daytime and nighttime noise of the same noise level is represented by a time-of-day weight in noise annoyance models. The high correlations between daytime and nighttime noise were regarded as a major reason that previous social surveys of noise annoyance could not accurately estimate the value of the time-of-day weight. Study designs which would reduce the correlation between daytime and nighttime noise are described. It is concluded that designs based on short term variations in nighttime noise levels would not be able to provide valid measures of response to nighttime noise. The accuracy of the estimate of the time-of-day weight is predicted for designs which are based on long term variations in nighttime noise levels. For these designs it is predicted that it is not possible to form satisfactorily precise estimates of the time-of-day weighting. Author

**N86-22312#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
**MEASUREMENT OF NOISE FROM AIRPLANES TRAVELING AT HEIGHTS 3500 TO 6000M**
M. LINDE and S. MEIJER Sep. 1985 19 p refs
(Contract STU-AU-2168)
(FFA-TI-AU-2168) Avail: NTIS HC A02/MF A01

The noise on the ground produced by overflights of jet and propeller airplanes, at different flight levels, was studied to provide a basis for the estimation of the noise from future propeller airplanes. The noise on the ground from airplanes at heights 3500 to 6000m was measured. Author (ESA)

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-26427#**
**RADIONAVIGATION PLANNING IN THE FAA**
N. A. BLAKE and J. W. BRADLEY (FAA, Washington, DC) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 5-17.

A review of the development and automation of the FAA's air traffic control process, in addition to its program for the future, is presented. The very high frequency omnidirectional radio range (VOR) in use since 1946 and updated to solid-state capability, and its distance measuring equipment (DME), constitute the primary civil air radio navigation systems today, and are projected to remain so into the next century. The system is supplemented by LORAN-C for low altitudes and offshore areas, and OMEGA and INS for oceanic and domestic high altitude airspace to meet all current user requirements including direct and random fuel efficient operation throughout much of the upper airspace. The Global Positioning System (GPS) may meet the requirements either as a sole-means or a supplementary navigation system in the future, accompanied by the possible phasing-out of existing supplementary systems. The military, however, plan to replace their tactical air navigation system (TACAN) with the GPS during the 1990s. R.R.

**A86-27834#**
**PRODUCTION-THEORETICAL STUDY OF AIR TRAFFIC OUTPUT PRODUCTION [PRODUKTIONSTHEORETISCHE UNTERSUCHUNG DER FLUGBETRIEBLICHEN LEISTUNGSERSTELLUNG]**
C. WEILER Koeln, Universitaet, Wirtschafts- und sozialwissenschaftliche Fakultaet, Doktor Dissertation, 1983, 239 p. In German. refs

The theory and application of production theory to air traffic is addressed. The formalities and systematics of the theory are discussed and applied ot the characterization and differentiation of combined aircraft operations. The empirical determination of the technical-economic use function for fuel and maintenance work is studied and formulated for the singular process. The combined usage function is applied to models of aircraft usage, and the factor-output relationship is characterized. C.D.

**A86-28425**
**SOFTWARE MANAGEMENT FOR INTEGRATED AVIONICS SYSTEMS**
K. C. EDWARDS (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 798-805. refs

Software engineering methodologies providing the level of control necessary to achieve cost effective software development for an integrated avionics software system are discussed with particular reference to the integrated software system for the Agusta A-129 Light Attack Helicopter. The high level of control is required to maintain the functional independence of the different software elements (e.g., Automated Flight Controls, Engine Monitor, Operator Interface, Navigation, and others) in order to avoid unnecessary couplings that will drive the cost of the system development and maintenance up while reducing the reliability of the system. As a result of an implementation of this approach, the software development costs for the Agusta A-129 project have been comparable to less complex ground-based systems. V.L.

**N86-21435#** National Bureau of Standards, Washington, D.C. Information Resources and Services Div.
**PUBLICATIONS OF THE NATIONAL BUREAU OF STANDARDS, 1984 CATALOG Report, Jan. - Dec. 1984**
R. J. MOREHOUSE Jun. 1985 441 p
(PB85-245678; NBS/SP-305-SUPPL-16) Avail: NTIS HC A19/MF A01; SOD HC $16.00 as 003-003-02667-1 CSCL 05B

The 16th Supplement to Special Publication 305 lists the 1984 papers which reflect the results of National Bureau of Standards (NBS) programs. Also included are those NBS papers published prior top 1984 but not reported in previous supplements of SP305. In addition to bibliographic data, key words, and abstracts for each publication and/or paper, the catalog provides author, key word, title, and NTIS order/report number indexes. GRA

**N86-21447#** Committee on Science and Technology (U. S. House).
**OVERSIGHT ON THE FEDERAL AVIATION ADMINISTRATION FISCAL YEAR 1986 RESEARCH, ENGINEERING AND DEVELOPMENT BUDGET REQUEST**
Washington GPO 1985 191 p Hearings before the Subcommittee on Transportation, Aviation and Materials of the Committee on Science and Technology, 99th Congr., 1st Sess., no. 8, 19-20 Mar. 1985
(GPO-46-725) Avail: Subcommittee on Transportation, Aviation and Materials

Hearings held by the House Committee on Science and Technology on the Federal Aviation Administration fiscal year 1986 research, engineering, and development budget requests are presented. Statements in support of the implementation of R & D programs in the National Airspace System Plan are presented. B.W.

**N86-22441#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**A METHODOLOGY FOR APPLYING BAR CODE TECHNOLOGY TO AIRCRAFT MAINTENANCE UNIT SUPPORT SECTIONS M.S. Thesis**
P. VALOVCIN Sep. 1985 97 p
(AD-A161783; AFIT/GLM/LSM/85S-79) Avail: NTIS HC A05/MF A01 CSCL 09B

This study developed a methodology that decision makers can use as an aid to determine if bar code technology should be applied in Aircraft Maintenance Unit (AMU) Support Sections. The literature review revealed that the Logistics Applications of Automated Marking and Reading Symbols (LOGMARS) steering group recommended that bar code technology applications be aggressively pursued across the logistics spectrum due to the success of the LOGMARS test program. Since AMU support sections perform many functions similar to those that have already benefited form this technology as it applies to an AMU support sections. Worksheets were designed to help collect and analyze the necessary cost/benefit information so that decision makers will be able to properly assess the expected cost and benefits for a particular support section. GRA

**N86-22443#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**AIR FORCE TECHNICAL OBJECTIVE DOCUMENT, FLIGHT DYNAMICS LABORATORY PLANS FOR FISCAL YEAR 1987 Final Report, Aug. 1984 - Jul. 1985**
Jul. 1985 75 p Supersedes AFWAL-TR-84-3000, AD-A149648
(AD-A162792; AFWAL-TR-85-3000; AFWAL-TR-84-3000) Avail: NTIS HC A04/MF A01 CSCL 01C

The document presents an overview of the Laboratory Technology Planning Objectives of the Flight Dynamics Laboratory omitting specific funding and timing information of an Official Use Only nature. Technology planning objectives are described for

Structures and Dynamics, Vehicle Equipment, Flight Control, Aeromechanics, and Technology Assessment. GRA

**N86-22450** Deutsche Lufthansa Aktiengesellschaft, Frankfurt am Main (West Germany).
**ACTIVITIES REPORT OF THE AEROSPACE INDUSTRY IN WEST GERMANY Annual Report, 1985 [LUFTHANSA JAHRBUCH 85]**
H. J. ALLGAIER, ed. 31 May 1985 360 p In GERMAN
(ISSN-0176-5086) Avail: Issuing Activity

Air traffic, air traffic market, efficiency, costs, Lufthansa national role and independence, and rates and regulation in civil aviation are discussed. The Airbus A320 program, the development of a propeller, the role of Lufthansa in aircraft development and in technical services, German cargo services, and aviation fuel are treated. Author (ESA)

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## GENERAL

**A86-27648**
**THE GOLDEN AGE OF THE GREAT PASSENGER AIRSHIPS: GRAF ZEPPELIN AND HINDENBURG**
H. G. DICK and D. H. ROBINSON Washington, DC, Smithsonian Institution Press, 1985, 226 p. refs

The history of commercial airship operations in Germany during the 1920s and 1930s is reviewed, in an anecdotal style. Emphasis is given to the personal reminiscences of an American airship designer on board the Graf Zeppelin and the Hindenburg during several transatlantic crossings. A description of the Hindenburg disaster at Lakehurst, New Jersey, on May 6, 1937, is presented. Some of the political and economic factors which led to the abandonment of commercial airship transportation are discussed in detail. Original black and white photographs of the Hindenburg and the Graf Zeppelin are provided, as well as a glossary of airship terms and a verbatim reproduction of a German airship crew manual. I.H.

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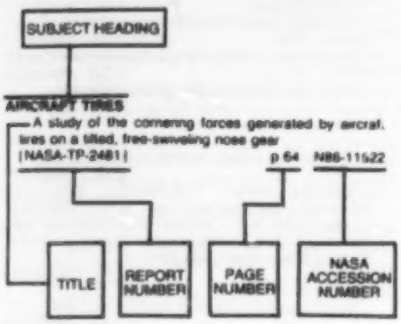
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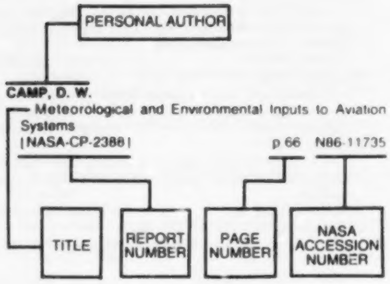

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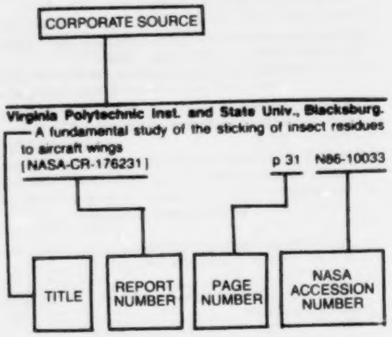
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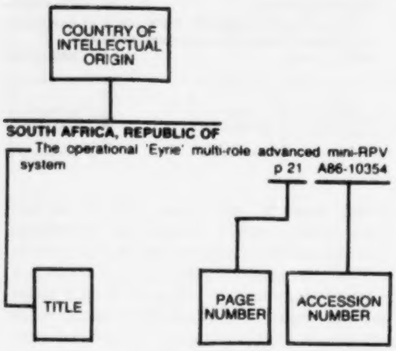
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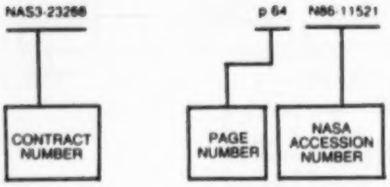

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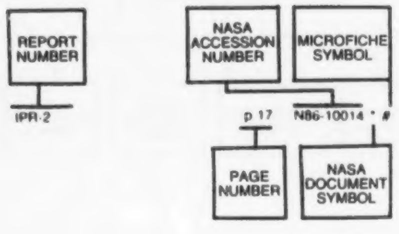

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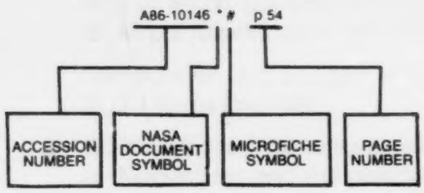

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# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY
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## (Supplement 203)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in July 1986 in

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 449 reports, journal articles, and other documents originally announced in June 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**Category 03 Air Transportation and Safety** 418

Includes passenger and cargo air transport operations; and aircraft accidents.

**Category 04 Aircraft Communications and Navigation** 421

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**Category 05 Aircraft Design, Testing and Performance** 425

Includes aircraft simulation technology.

**Category 06 Aircraft Instrumentation** 438

Includes cockpit and cabin display devices; and flight instruments.

**Category 07 Aircraft Propulsion and Power** 440

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**Category 08 Aircraft Stability and Control** 442

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**Category 09 Research and Support Facilities (Air)** 446

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**Category 10 Astronautics** 449

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**Category 11 Chemistry and Materials** 449

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**Category 12 Engineering** 453
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Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**Category 16 Physics** 467
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**Category 17 Social Sciences** 470
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**Category 18 Space Sciences** N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

**Category 19 General** N.A.

**Subject Index** ........ A-1
**Personal Author Index** ........ B-1
**Corporate Source Index** ........ C-1
**Foreign Technology Index** ........ D-1
**Contract Number Index** ........ E-1
**Report Number Index** ........ F-1
**Accession Number Index** ........ G-1

## TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE

ACCESSION NUMBER → **N86-10033*#** Virginia Polytechnic Inst. and State Univ., ← CORPORATE SOURCE
Blacksburg. Dept. of Chemistry.
TITLE → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
AUTHORS → N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs ← PUBLICATION DATE
← AVAILABILITY SOURCE
CONTRACT NUMBER → (Contract NAG1-300)
REPORT NUMBERS → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 ← PRICE CODE
COSATI CODE → CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.
Author

## TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE

ACCESSION NUMBER → **A86-11041*#** National Aeronautics and Space Administration.
Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS** ← TITLE
AUTHOR → D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) ← AUTHOR'S AFFILIATION
CONFERENCE TITLE → AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs ← CONFERENCE DATE
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.
Author

# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 203)*

AUGUST 1986

## 01

## AERONAUTICS (GENERAL)

**A86-29868#**
**THE HISTORY OF INSTRUMENT FLIGHT**
W. R. ERCOLINE (USAF, Instrument Flight Center, Randolph AFB, TX) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 167-173.

It is pointed out that the first instrument ever used on an aircraft was invented by Wilbur and Orville Wright, and consisted of a piece of string placed in the air stream directly in front of the pilot. Gradually, it was realized that a pilot's equilibrium does not depend on the semicircular canals of the inner ear and the muscular sense, but on the visual sense. This development led to the invention of the 'Vertigo Stopper Box' by Ocker, and to the publication of the book 'Blind Flight in Theory and Practice', coauthored by Ocker and Crane in 1932. Another advance due to Crane was the first instrument simulator with ratio guidance features for instrument flight training applications. In tests conducted in 1930, it was found that Crane's flight integrator made it possible to eliminate vertigo, while the first blind landing was performed by Doolittle in 1929. Attention is also given to the evolution of the USAF Instrument Flight Center, and the possible advantages of the Crane Flitegage. G.R.

**A86-30549**
**HELICOPTER MAINTENANCE IN THE REAL WORLD**
G. R. VANSLYKE (Okanagan Helicopters, Ltd., Richmond, Canada) Vertiflite (ISSN 0042-4455), vol. 32, Mar.-Apr. 1986, p. 24-28.

The need to minimize helicopter operating and maintenance costs and improve reliability and durability is examined. It is estimated that large current generation helicopters cost $1,000/flying hour; the largest cost is engine repair followed by accessory repair. The improvements required in field maintenance, repair shop maintenance, and helicopter and engine design and developments are described. The use of in-house repair services and overhaul capabilities has reduced maintenance costs. The elimination of helicopter design problems such as vibrations, corrosion, water leaking, and the removal of finite-lifted components, by the manufacturer is studied. I.F.

**A86-31038**
**WHAT TECHNOLOGIES AWAIT THE FUTURE AIRLINER?**
P. CONDOM and M. LAMBERT Interavia (ISSN 0020-5168), vol. 41, Feb. 1986, p. 145-149.

The present assessment of technology readiness in the fields of airliner aerodynamics, structures, avionics, control systems, and propulsion, attempts to forecast the likely character of the next generation in commercial aircraft design. Although both political and commercial pressures exist for renewed efforts toward a second-generation SST, current technology development efforts are centered on continued refinement of laminar aerodynamics, propfan and unducted fan propulsion, thermoplastic matrix composites and aluminum-lithium alloys for structures and digital avionics and control. Attention is given to the boundary layer wing-skin suction flow laminarization technique and the competition between engine manufacturer's innovative propfan technologies. O.C.

**A86-31330#**
**X-AIRCRAFT FOR WORLD LEADERSHIP IN AERONAUTICS**
R. S. COOPER Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 26-28.

Continuing vigorous and sufficiently funded aeronautical research involving experimental aircraft is a necessity if the U.S. is to retain world leadership in aerospace defense and industrial technologies. The most recent program, the X-29, illustrates the process of demonstrating a proof of concept as a key effort in introducing new ideas into operational aircraft. The alternative to flight testing experimental demonstrator aircraft can be several years of studies in wind tunnels and in computer time, substantially increasing program costs and usually producing only an incremental increase in performance instead of an integer multiplicative advance. The next likely demonstrator program will be the DARPA-NASA X-wing circulation control (CC) rotor aircraft. CC experiments will examine techniques for generating lift, providing distributed propulsion and controlling drag, concepts which may eventually be applied in long-endurance high altitude atmospheric aircraft that may replace geosynchronous satellites. A subsequent program to develop a hydrogen-fueled aerospaceplane powered by a supersonic-combustion ramjet propulsion system may encounter funding obstacles when the time comes to construct a demonstrator experimental aircraft near the end of the 1980s. M.S.K.

**A86-31340#**
**HOW SWEDEN DECIDED TO BUILD THE GRIPEN**
S.-O. HOEKBORG (Forsvaret Materielverk, Stockholm, Sweden) Aerospace America (ISSN 0740-722X), vol. 24, March 1986, p. 48-50.

The Swedish aerospace defense industry was initiated in the 1940s after foreign manufacturers failed to make deliveries. The series of aircraft that followed included the J-29 Flying Barrel, first operational in 1951, followed by the 32-Lansen, the J-35 Draken (early delta-wing configuration), and the 37 Viggen. Budgetary constraints starting in the 1970s increased the need for a multirole fighter such as the F-16. When the Swedish government began considering foreign fighters such as the F-16 and Mirage 2000, a consortium of Swedish aerospace firms was formed, which developed a proposal for the JAS-39 Gripen. The design was accepted by the Swedish government as the Swedish multirole fighter into the 21st century. It is noted that the prospects of keeping the aerospace employment levels high in Sweden was an influential factor in the decision. M.S.K.

**A86-31848**
**EXPERT SYSTEMS IN THE FIGHTER OF THE 1990S**
R. M. YANNONE (General Electric Co., Aerospace Electronic Systems Dept., Utica, NY) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, Feb. 1986, p. 12-16.

The development of a multibeam system for the Advanced Tactical Fighter based on mission requirements is examined. The multisensor data fusion and situation assessment expert systems are described. The fusion sensor operates over a region of the surveillance volume asynchronously and provides data to maximize target identification and kinematic state vector accuracy. The measurement set level, track file level, and onboard common aperture arrangements for the fusion system are discussed. A block diagram for processing the autonomous sensor track files is provided. The situation assessment control sensor utilizes real-time sensor and historical data to provide display parameters for the pilots, weapon cueing, countermeasure response management, and data collection direction. A table listing the subprocesses of the two expert systems is presented. I.F.

**A86-32085#**

**COMBINED TEST FORCE OPERATIONS AT THE AIR FORCE FLIGHT TEST CENTER**

P. D. KENNEDY (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p.
(AIAA PAPER 86-9739)

In the interest of time and cost reductions, all major aircraft acquisitions by the U.S. Air Force have since 1972 undergone combined Development Test and Evaluation/Operational Test and Evaluation. The Combined Test Force (CTF) manages the planning and execution of such programs. All support resources are gathered at a single test location, and data are furnished to all participants from a common data base. Attention is presently given to the advantages and disadvantages of the CTF approach; the principal advantages include earlier military participation and total Air Force involvement. O.C.

**A86-32086#**

**PRINCIPAL SITE TESTING CONCEPT WITHIN THE NAVY**

J. L. DUNN (U.S. Naval Air Test Center, Patuxent River, MD) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, amd SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 4 p.
(AIAA PAPER 86-9740)

The U.S. Naval Air Test Center began Full Scale Development of the F-18 in 1975 with the goal of eliminating the duplication in facilities, logistics, and test data that previous test programs, involving both Navy and contractor facilities, had generated. The principal site concept employed in the Test Center colocated all test assets, which encompassed developmental aircraft, contractor and Navy test personnel, maintenance personnel, and all unique test equipment. Success with the F-18 led to similar programs for the AV 8B and LAMPS MK III aircraft. O.C.

**A86-32087#**

**PRINCIPLES OF FLIGHT TEST**

J. R. LARGENT (California, University, Los Angeles) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9742)

This paper discusses a major shortcoming of the conduct of flight test, identifies factors which may aggravate this shortcoming, and proposes a solution. The key to success for this solution is the proper understanding and application of the principles of flight test. Although this paper is based on a lecture given as a part of a continuing education course on Avionics Systems Engineering, the principles described in this paper are generic in nature and are applicable to any system. This paper also describes some methods for applying these principles and identifies some potential pitfalls. Author

**A86-32088#**

**LONG RANGE PLANNING FOR FLIGHT TEST SUPPORT**

C. R. HOPPING (USAF, Flight Test Center, Edwards AFB, CA), R. L. COUNTS, and T. A. SCANLAN (BDM Corp., Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9744)

The U.S. Air Force Flight Test Center has initiated a program for the modernization and improvement of both the Edwards Flight Test Range and the Utah Test and Training Range. Future technical facility requirements have been identified and master planning methods to meet those requirements have been formulated. The goal of these activities is to project requirements, capabilities, funding, procurement actions, and construction programs sufficiently far in advance to ensure adequate support for near future flight test support needs. O.C.

**A86-32094#**

**OPERATIONAL SUITABILITY EVALUATION OF A TACTICAL FIGHTER SYSTEM**

A. C. DEMENT and R. D. HARTMAN (USAF, Operational Test and Evaluation Center, Kirtland AFB, NM) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9753)

A tactical fighter is presently evaluated by the U.S. Air Force's Operational Test and Evaluation Center (AFOTEC) methodology. AFOTEC develops a test plan and a separate data management plan to support the suitability evaluation. After data have been gathered by the AFOTEC test team, a Joint Reliability and Maintainability Evaluation Team categorizes failure data that AFOTEC can employ as a data base for analysis. After the system's current status is assessed, a projection of system maturity is made on the basis of techniques in Military Handbook 189, 'Reliability Growth Management'. Mature reliability projections, maintenance task times, and the planned logistics support structure are inputs to the availability analysis; this uses computer simulations developed or modified in-house. O.C.

**A86-32149#**

**AIAA-86-9827 F-16 RADAR FLIGHT TEST A LESSON IN SOFTWARE DEVELOPMENT**

J. KELLEY (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9827)

The effects of software development on flight testing of aircraft equipment are investigated. Problems which have evolved in developing software are reviewed. The need for ground testing and two phase flight testing (software and specification compliance) of aircraft components is examined. The relationship between the government and contractors concerning software delivery schedules is discussed. An example decribing the flight testing problems encountered in the software development of the AN/APG-68 Fire Control Radar is provided. I.F.

**A86-33226**

**INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS, 2ND, RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE, AACHEN, WEST GERMANY, APRIL 1-3, 1985, COLLECTED PAPERS**

Symposium organized by DGLR; Supported by BMFT. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, 713 p. For individual items see A86-33227 to A86-33261, A86-33263 to A86-33291.
(DGLR BERICHT 85-02)

The present conference considers topics in the unsteady aerodynamics and aeroelastic characteristics of aircraft structures, active structural control technologies, structural modeling and optimization methods, structural system identification, and the structural dynamics design verification of space structures. Specific attention is given to the transonic equivalent strip method for aeroelastic applications, transonic unsteady methods for the calculation of flutter airloads, experimental and analytical buffeting investigations of a delta wing, the application of unsteady wing collocation methods to subsonic flow cascades, a static aeroelastic analysis employing aircraft vibration modes, and a general theory for the finite state modeling of aeroelastic systems for active control applications. Also discussed are the use of control law synthesis for gust load alleviation using linear quadratic Gaussian theory, the stiffness control of large space structures, the variation of isotropic behavior in structural optimization, the dynamic analysis of structures with flexible rotors, modal parameter estimation from driven-base tests, rapid vibration mode analysis of aircraft with external stores, and low frequency design verification of large spacecraft structures. O.C.

**A86-33300**
**INTERNATIONAL HELICOPTER FORUM, 15TH AND INTERNATIONAL AEROSPACE EXHIBITION, HANOVER, WEST GERMANY, MAY 20-27, 1984, REPORTS [INTERNATIONALES HUBSCHRAUBERFORUM, 15TH AND INTERNATIONALE LUFTFAHRT-AUSSTELLUNG, HANOVER, WEST GERMANY, MAY 20-27, 1984, VORTRAEGE]**
Bueckeburg, West Germany, Helicopter Center, 1984, 151 p. In German. No individual items are abstracted in this volume.

Various papers on helicopter technology are presented. The topics considered include: military helicopters of the future; Boeing helicopter meeting today's and tomorrow's requirements; new possibilities for fighting helicopters; expanding the applications of military helicopters; and the role of industry in finding military uses for helicopters. Also discussed are: characteristics of the fighting manned helicopters of the future; the new military technologies program at Bell; Project A129, the Army's airborne antitank weapons system; the role of research in future helicopter developments; the influence of new technologies on the design and operation of future helicopter engines; and high technology equipment in aircraft. C.D.

**N86-22537#** Selenia Industrie Associate S.p.A., Rome (Italy).
**RIVISTA TECHNICA SELENIA, VOLUME 9, NUMBER 3, 1985**
1985 36 p refs
Avail: NTIS HC A03/MF A01

Electronic and communication automatic test systems are discussed, referring to the Tornado combat aircraft test systems. The subjects include system architecture, the role of advanced computer languages, software quality control, system design analysis and evolution trends.

**N86-22538#** Selenia Industrie Associate S.p.A., Rome (Italy).
**THE MRCA AUTOMATIC TEST SYSTEM**
P. CECCHINI *In its* Rivista Technica Selenia, Vol. 9, No. 3, 1985 p 1-6 1985 refs
Avail: NTIS HC A03/MF A01

The automatic test system used to test the Tornado aircraft is described. Each piece of test equipment is dedicated to a single technological class, defined on the basis of the frequency range at which it operates, from low frequency to microwave. Avionics is conceived as a set of line replacable units tested at self standing test stations including a controller, switching devices, input-output interfaces, and appropriate instrumental configuration (dedicated or common) which carry out the test under the test control program. The interface with the operator is a video display unit. As an example of system performance, the flight computer control time is reduced to one tenth of the normal time required.
Author (ESA)

**N86-22539#** Selenia Industrie Associate S.p.A., Rome (Italy). Aircraft Support Equipment Group.
**COMPLEX SYSTEMS INTEGRATED LOGISTIC SUPPORT: AUTOMATIC TEST EQUIPMENT (ATE) AND TEST ORIENTED LANGUAGES ROLE**
S. DERCOLE *In its* Rivista Technica Selenia, Vol. 9, No. 3, 1985 p 7-11 1985 refs
Avail: NTIS HC A03/MF A01

The choice of language to be used in software design of automatic test equipment is discussed. The Abbreviated Test Language for Avionics Systems (ATLAS) is described and its performances are compared with those of Basic. A very important aspect introduced by ATLAS is that a change of the intrumentation used has no impact on an ATLAS test program. An example of the same program written in ATLAS and in Basic is given. It is also shown that the ATLAS program is considerably shorter.
Author (ESA)

**N86-22540#** Selenia Industrie Associate S.p.A., Rome (Italy). Aircraft Support Equipment Group.
**SELENIA'S CONTRIBUTION TO THE DEVELOPMENT OF SYSTEMS SUPPORT: MICROWAVE AUTOMATIC TEST EQUIPMENT (ATE)**
A. TULLI *In its* Rivista Technica Selenia, Vol. 9, No. 3, 1985 p 12-16 1985
Avail: NTIS HC A03/MF A01

The facilities to support onboard radar systems, (active and passive) are described. A fundamental characteristic of the system is that the test simulates the whole of the operational conditions of the equipment itself. The system is implemented by functional elements including the test equipment, hydraulic system, dedicated boards and units, and line replacable unit adapters. The software is divided into base and applications, and is writen in ATLAS language. Author (ESA)

**N86-22542#** Selenia Industrie Associate S.p.A., Rome (Italy). Aircraft Support Equipment Group.
**IMPLICIT ACTIVITIES IN THE POST DEVELOPMENT PHASE**
A. TULLI and S. DERCOLE *In its* Rivista Technica Selenia, Vol. 9, No. 3, 1985 p 22-27 1985
Avail: NTIS HC A03/MF A01

Development aspects of automatic test equipment to be supplied to a customer are discussed. A problem arises when a test system evolves after delivery. A study for third level support of automatic test equipment developed for second order level maintenance of the Tornado combat aircraft is included. Configuration control in three distinct intervention areas (documentation, hardware, and control) is also discussed.
Author (ESA)

**N86-22543#** Selenia Industrie Associate S.p.A., Rome (Italy). Aircraft Support Equipment Group.
**LINES OF EVOLUTION**
A. TULLI *In its* Rivista Technica Selenia, Vol. 9, No. 3, 1985 p 28-31 1985
Avail: NTIS HC A03/MF A01

Advice on electronic test equipment choice criteria is given. The configuration and modularity of hardware and software are examined. Global life cycle cost is negotiable against efficiency parameters at an early stage of system design. Author (ESA)

**N86-22545#** Joint Publications Research Service, Arlington, Va.
**SCIENTISTS ON AIRCRAFT DEVELOPMENT TRENDS**
M. GOLUBEVA and V. ZASIMOV *In its* USSR Report: Transportation (JPRS-UTR-86-001) p 1-5 24 Jan. 1986 Transl. into ENGLISH from Grazhdanskaya Aviatsiya (Moscow, USSR), no. 9, Sep. 1985 p 22-23
Avail: NTIS HC A04

Fuel consumption and the production of aircrafts and aviation fuels is discussed. Problems in producing synthetic fuels from shale oil, bituminous coal, and hydrogen are outlined. Fuel conservation which should be configurated in aircraft design, materials, and construction is discussed. Polymer composites for use in aircraft construction, such as high modulus fibers of graphite and boron are recommended. It is concluded that the introduction of the new technologies will improve aircraft performance and fuel efficiency. E.A.K.

**N86-22775#** Joint Publications Research Service, Arlington, Va.
**FUZZY INFERENCE SYSTEM TO DIAGNOSE AIRCRAFT HYDRAULIC FAULTS**
S. FENG, W. WENG, and L. DONG *In its* China Report: Science and Technology (JPRS-CST-86-010) p 134-141 19 Mar. 1986 refs Transl. into ENGLISH from Shuxue de Shijian yu Renshi (Beijing, China), no. 3, Jul. 1985 p 14-18
Avail: NTIS HC A08/MF A01

Aircraft hydraulic systems, the drive systems which control attitude, extension and retraction of landing gear, and wing flaps, are composed of tens to over a hundred parts. These systems are complex and often give rise to puzzling faults. The application of computers in fault diagnosis can increase precision and speed so as to conveniently array the prerequisites which create the fault. This is one effective way to improve the quality of aircraft maintenance. The causes of system faults and the appearance of symptoms have a random or Fuzzy nature. In the process of diagnosis the language people use is also largely vague. Based on these statistics combined with fault mechanism analysis, this article takes natural languages and transforms it into machine language and crystallize human experience to simulate a Fuzzy inference system. The characteristic nature of the system is first to select from events a set of symptoms (input) and causes (output) of model fault events and store them in a computer. Then during diagnosis an input works in this system to diagnose the causes (output). B.W.

**N86-23552*** National Aeronautics and Space Administration, Washington, D.C.
**A CUMULATIVE INDEX TO A CONTINUING BIBLIOGRAPHY ON AERONAUTICAL ENGINEERING**
1986 521 p
(NASA-SP-7037(196); NAS 1.21:7037(196)) Avail: NTIS HC A22 CSCL 01A

This bibliography is a cumulative index to the abstracts contained in NASA-SP-7037(184) through NASA-SP-7037(195) of Aeronautical Engineering: A Continuing Bibliography. NASA SP-7037 and its supplements have been compiled through the cooperative efforts of the American Institute of Aeronautics and Astronautics (AIAA) and the National Aeronautics and Space Administration (NASA). This cumulative index includes subject, personal author, corporate source, foreign technology, contract, report number, and accession number indexes. Author

**N86-23553*** National Aeronautics and Space Administration, Washington, D.C.
**AERONAUTICAL ENGINEERING (A CONTINUING BIBLIOGRAPHY WITH INDEXES)**
Mar. 1986 115 p
(NASA-SP-7037(198); NAS 1.21:7037(198)) Avail: NTIS HC A06 CSCL 01A

This bibliography lists 395 reports, articles, and other documents introduced into the NASA scientific and technical information system in February 1986. Author

**N86-23554*#** Kentron International, Inc., Hampton, Va.
**AN AERODYNAMIC ANALYSIS COMPUTER PROGRAM AND DESIGN NOTES FOR LOW SPEED WING FLAP SYSTEMS Final Report**
H. W. CARLSON and K. B. WALKLEY Washington NASA Mar. 1983 75 p refs
(Contract NAS1-16000)
(NASA-CR-3675; NAS 1.26:3675) Avail: NTIS HC A04/MF A01 CSCL 01B

The expanded capabilities for analysis and design of low speed flap systems afforded by recent modifications of an existing computer program is described. The program provides for the simultaneous analysis of up to 25 pairs of leading-edge and trailing-edge flap deflection schedules. Among other new features of the program are a revised attainable thrust estimation method to provide more accurate predictions for low Mach numbers, and a choice of three options for estimation of leading-edge separation vortex flow effects. Comparison of program results with low speed experimental data for an arrow wing supersonic cruise configuration with leading-edge and trailing-edge flaps showed good agreement over most of the range of flap deflections. Other force data comparisons and an independent study of airfoil and wing pressure distributions indicated that wind-tunnel measurements of the aerodynamic performance of twisted and cambered wings and wings with leading-edge flaps can be very sensitive to Reynolds number effects. Author

**N86-23555*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**SOME LESSONS LEARNED WITH WIND TUNNELS**
M. L. SPEARMAN Mar. 1986 40 p refs
(NASA-TM-87710; NAS 1.15:87710) Avail: NTIS HC A03/MF A01 CSCL 01B

A review is presented of some of the lessons learned from wind tunnel tests since World War II. Wind tunnels achieved a very high productivity rate during the war due in part to development testing of numerous military aircraft concepts. Following the war, in addition to development testing, a rapid increase in basic research testing occurred in order to explore areas of interest revealed by the conduct of war and to expand on advanced technology that became available from Germany and Italy. The research test areas discussed are those primarily related to the transition from subsonic flight to supersonic flight. Author

**N86-23556#** RAND Corp., Santa Monica, Calif.
**DEPOT MAINTENANCE OF AVIATION COMPONENTS: CONTRACTOR VERSUS ORGANIC REPAIR**
L. B. EMBRY, N. Y. MOORE, J. CAVE, and F. LABRUNE Mar. 1985 116 p
(Contract N00014-83-C-0100)
(AD-A162071; RAND/N-2225-NAVY) Avail: NTIS HC A06/MF A01 CSCL 01C

Aviation and engine component repair requirements make up over half of the projected wartime depot-level maintenance workload. Organic (service-owned) ability to support this workload is particularly limited; at present, nearly half of the Navy's depot-level component repair is performed in contractor or other service facilities. Before major investments are made in the facilities and equipment needed to accomplish these repairs, it will be necessary to determine the appropriate mix of organic and contractor repair sources. This note addresses the economic and operational implications of alternative source-of-repair decisions. Based on analyses of the distribution of projected wartime demands, technical data limitations, the structure of the repair industry, the operational payoff of facilities characterized by broad scope of repair, and airline industry practices, it postulates a strategy for providing depot-level component support that can be used to specify the appropriate source of repair at different points in the weapon system and subsystem life cycle. GRA

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-30213#**
**RECOMBINATION OF VORTEX FILAMENTS AND ITS ROLE IN AERODYNAMIC NOISE**
R. TAKAKI (Tokyo University of Agriculture and Technology, Fuchu, Japan) and A. K. M. F. HUSSAIN (Houston, University, TX) IN: Symposium on Turbulent Shear Flows, 5th, Ithaca, NY, August 7-9, 1985, Proceedings . University Park, PA, Pennsylvania State University, 1985, p. 3.19-3.25. refs
(Contract NSF MEA-81-11676; NSF INT-84-14714)

The recombination of two vortex filaments in a viscous incompressible fluid is analyzed by the use of the vorticity equation. The analysis is confined to a local flow field where the recombination process occurs, and is based on several assumptions, such as conservation of the fluid impulse, spatial symmetry of the flow field, etc. The flow field is expanded as polynomials of coordinates, and variations of their coefficients are obtained by the use of the vorticity equation. It is proved that the process is completed within a short time of 0(sigma-squared/Gamma), and that the viscous effect is essential; sigma and Gamma are the size and the circulation of the filaments, respectively. The result is applied to predict the far-field noise of a circular jet by assuming that the main noise source is the recombination process in deformed vortex rings in the jet near field. The predicted noise intensity shows the U to the 8th dependence and has an additional new factor (d/sigma) to the 6th; U is the jet velocity and d is the average spacing between vortex rings. The predicted intensity distribution is directional even without the effect of source convection. Author

**A86-30734#**

**A METHOD FOR COMPUTER AIDED DESIGN OF TRANSONIC TURBINE CASCADE**

Y. AHAO, T. ZHAN, H. XIAO, J. ZHENG, and Z. WU (Nanhua Power Plant Reseach Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Oct. 1985, p. 449-454. In Chinese, with abstract in English.

A computer-aided design method for transonic turbine aerofoil shaping and thermodynamic analysis is presented. The method adopts the technique of 'Computational Geometry' developed for blade space shaping. An improved Streamline Curvature method for cascade analysis, called CASC, is applied to blade-to-blade stream surface analysis. Its advantage over the conventional streamline curvature method lies in using oblique computational stations. On the basis of choosing the throat as a basic computational station, all oblique computational stations are generated from input data by circular spline fitting and interpolating. A high-loaded turbine cascade with anti-convex suction surface near the trailing edge has been designed with success by this method. Its appreciable supersonic performance is proven in wind tunnel tests. This method is a core module of a 'Turbine Blade Computer Aided Design System' (GTCAD). Author

**A86-31013#**

**EFFECTS OF INTENSE RAINFALL ON THE AERODYNAMICS OF AN AIRFOIL PROFILE [EFECTOS DE LA LLUVIA INTENSA SOBRE LA AERODINAMICA DE UN PERFIL]**

A. FEO PALACIOS (Instituto Nacional de Tecnica Aeroespacial, Madrid, Spain) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Jan. 1986, p. 35-41. In Spanish. refs

Recent studies have indicated that the effects of intense rainfall on aircraft lift can catastrophically degrade flight capabilities in the presence of other adverse atmospheric conditions. Attention is presently given, first, to several illustrative case histories, and then to a physical description of the characteristics of intense rainfall. Quantitative rainfall effects on NACA and Wortman airfoil profiles obtained by previous studies are noted. O.C.

**A86-31020#**

**A CORRECTION OF THE ANGLE OF INCIDENCE FOR A TWO-DIMENSIONAL WING MODEL IN THE CLOSED TEST SECTION**

K. ABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 383, 1985, p. 689-696. In Japanese, with abstract in English. refs

In low-speed wind tunnel testing for a two-dimensional wing model, a correction to the angle of incidence is considered due to the nonuniform spanwise distribution of lift. This phenomenon is concerned with the change of the effective angle of incidence, which results from the interference between the wing tip and tunnel wall perpendicular to the wing span. Since the change of the effective angle of incidence is connected with the induced drag according to the lifting-line wing theory, the change of the effective angle of incidence may be estimated if the induced drag could be determined by experiment. In this study, the induced drag is obtained by the difference between the total drag measured by the wind tunnel balance and the profile drag determined by the wake measurements. The result with this correction to the angle of incidence is in good agreement with reliable experimental data. Author

**A86-31021#**

**IMPROVED NUMERICAL METHOD FOR LIFTING AIRFOILS WITH OSCILLATING CONTROL SURFACES IN SUBSONIC FLOW**

A. ICHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 383, 1985, p. 697-703. In Japanese, with abstract in English. refs

A numerical method is presented for the prediction of unsteady loadings on lifting airfoils that are due to oscillations of trailing edge control surfaces in subsonic compressible flow. An asymptotic pressure distribution is used to remove and separately evaluate the singularity in the kinematic downwash distribution. The method gives accurate result, quick convergence and excellent computational efficiency to other current methods. Author

**A86-31022#**

**OUTER SURFACE OF AIRPLANE AND COMPUTATIONAL GRID FOR FLOW ANALYSIS IN PHYSICAL SPACE**

M. NAKAMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 383, 1985, p. 704-709. In Japanese, with abstract in English.

For the purpose of numerical analysis of three-dimensional compressible steady flow around an airplane, it is necessary to find quantitatively local positions of an outer surface of the airplane and local directions of the surface in a rectangular computational grid system in physical space. The outer surface of the airplane is made up of many elements of small triangular planes. The local positions of the outer surface in the grid system are determined by local interactions of axes of the grid with these triangular planes. Directions of the triangular planes are substituted for the local directions of the outer surfaces. Using these results, views of the outer surface of airplane are drawn in sheets of paper. Author

**A86-31132**

**ON THE EXACT SOLUTION OF THE LINEARIZED LIFTING-SURFACE PROBLEM OF AN ELLIPTIC WING**

A. HAUPTMAN and T. MILOH (Tel Aviv University, Israel) Quarterly Journal of Mechanics and Applied Mathematics (ISSN 0033-5614), vol. 39, Feb. 1986, p. 41-66. refs

An analytic solution is presented for the lifting-surface problem of a thin circular or elliptic wing in steady incompressible potential flow. The analysis is based on expansion of the acceleration potential in an infinite series of ellipsoidal harmonics. Unlike previous analyses, which involve inversion of infinite sets of linear equations or the numerical solution of integral equations, the present method leads to rather simple explicit expressions for the lift and moment coefficients in terms of the aspect ratio. These expressions are valid in the whole range of aspect ratios from the two-dimensional airfoil through the circular wing to the slender wing. Author

**A86-32154#**

**UNSTEADY STALL MODELLING IN THREE-DIMENSIONAL FLOW**

C. COSTES, J. J. COSTES, and D. PETOT (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 4, 1985, p. 59-61. refs

A two-dimensional model that determines aerodynamic forces using nonlinear coupled differential equations is presented. The model expresses nonlinear and three-dimensional effects. The application of the model to the evaluation of unsteady aerodynamic forces on a straight rectangular wing model is described; data for large-amplitude oscillations at zero sweep are obtained. Experimental and theoretical data are compared and good correlation is observed. I.F.

**A86-32324#**

**AIRCRAFT AND ROCKETS: DESIGN CONCEPTS [AVIOANE SI RACHETE: CONCEPTE DE PROIECTARE]**

M. M. NIA, F. V. MORARU, and R. N. PATRAULEA Bucharest, Editura Militara, 1985, 303 p. In Romanian. refs

After a brief historical review of the Romanian aviation, the book details design concepts and principles of aircraft and rocket construction and aerodynamics. Topics discussed include wing geometry and profiles (NACA, ONERA, Tsagi, RAF), aileron and flap theory, and fuselage construction; also discussed are aerodynamics of the tail ensemble and lift and drag problems. Rocket subjects include supersonic flight regimes, ballistic laws and trajectory and reentry theories. Angle-of-attack and angle-of-incidence computations are presented, together with theories and problems of the propeller and jet propulsion systems. The book is recommended for academic as well as military circles. N.D.

**A86-32739**

**FLOW STRUCTURE AT THE WINDWARD SIDE OF CONICAL WINGS WITH AN ATTACHED SHOCK WAVE AT THE LEADING EDGE [O STRUKTURE TECHENIIA OKOLO NAVETRENNOI STORONY V-OBRAZNYKH KRYL'EV S PRISOEDINENNOI UDARNOI VOLNOI NA PEREDNIKH KROMKAKH]**

M. A. ZUBIN and N. A. OSTAPENKO Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1986, p. 122-131. In Russian. refs

Results of numerical calculations of symmetric supersonic flow of a gas past the windward side of conical wings with a dihedral angle of 40 deg and apex angles of 30, 45, and 90 deg are presented for Mach 3. The fact that one or two Ferri points may move up from the corner point of the wing profile is discovered and explained. It is shown that conical flow past wings of finite length may discontinue at regimes corresponding to angles of attack at which the Ferri point moves up. V.L.

**A86-32777#**

**EXPERIMENTAL ANALYSIS OF A PITOT-TYPE AIR INTAKE**

D. WELTE (Dornier GmbH, Friedrichshafen, West Germany) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 266-274. Research supported by the Bundesministerium der Verteidigung. Previously cited in issue 20, p. 2845, Accession no. A84-41350.

**A86-32779#**

**SOLUTION OF THE UNSTEADY EULER EQUATIONS FOR FIXED AND ROTOR WING CONFIGURATIONS**

N. L. SANKAR, B. E. WAKE, and S. G. LEKOUDIS (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 283-289. Army-supported research. Previously cited in issue 07, p. 838, Accession no. A85-19531. refs

**A86-32780*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**UNSTEADY TRANSONIC FLOW CALCULATIONS FOR TWO-DIMENSIONAL CANARD-WING CONFIGURATIONS**

J. T. BATINA (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 1-9) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 290-298. Previously cited in issue 13, p. 1845, Accession no. A85-30320. refs

**A86-32781#**

**COMPUTATION OF PROP-FAN ENGINE INSTALLATION AERODYNAMICS**

C. W. BOPPE and B. S. ROSEN (Grumman Aerospace Corp., Bethpage, NY) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 580-590) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 299-305. Previously cited in issue 22, p. 3172, Accession no. A84-44994. refs

**A86-32782*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMIC PARAMETERS ESTIMATED FROM FLIGHT AND WIND TUNNEL DATA**

V. KLEIN (NASA, Langley Research Center; Joint Institute for Advancement of Flight Sciences, Hampton, VA) and J. G. BATTERSON (NASA, Langley Research Center, Hampton, VA) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1038-1046) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 306-312. Previously cited in issue 22, p. 3197, Accession no. A84-45042. refs

**A86-32784#**

**INVESTIGATION OF VORTEX PATTERNS ON SLENDER BODIES AT HIGH ANGLES OF ATTACK**

G. WU, T. WANG, and S. TIAN (Nanjing Aeronautical Institute, People's Republic of China) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 763-771) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 321-325. Previously cited in issue 22, p. 3173, Accession no. A84-45012. refs

**A86-32785#**

**OPTIMUM SUPERSONIC WINGS WITH SUBSONIC LEADING EDGES**

H. J. BOS (Delft, Technische Hogeschool, Netherlands) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1256-1262) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 326-332. Previously cited in issue 22, p. 3175, Accession no. A84-45069. refs

**A86-32789#**

**EXPERIMENTAL AND THEORETICAL STUDY OF WINGS WITH BLUNT TRAILING EDGES**

V. RAMJEE, E. G. TULAPURKARA, and V. BALABASKARAN (Indian Institute of Technology, Madras, India) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 349-352. refs

The effects of blunt trailing edges on the performance of an aircraft are experimentally and theoretically evaluated. A teak wood model with sharp trailing-edged wings and a chord of 0.2 m, and four models with blunt trailing edges and chords of 0.19, 0.18, 0.17, and 0.16 m are tested at the speed of 32 m/s. The lift coefficient, wing drag, slope of the lift curve, and aerodynamic efficiency are examined. The data reveal that for a slightly blunt trailing edge there is no significant affect on aerodynamic characteristics; however, when the bluntness increased the slope of the lift curve, the maximum lift coefficient, and drag coefficient increase and the aerodynamic efficiency decreases. The simplified Martensen surface vorticity technique of Lewis (1980) is used to calculate potential flow past airfoils with blunt trailing edges. It is observed that the slope of the lift curve increases from 0.1195 to 0.138 when the cutoff is increased from 0-50 percent of the chord. I.F.

**A86-32959#**

**AERODYNAMIC CHARACTERISTICS OF A FLEXIBLE MEMBRANE WING**

S. GREENHALGH (U.S. Navy, Naval Air Development Center, Warminster, PA) and H. C. CURTISS, JR. (Princeton University, NJ) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 545-551. refs

(AIAA PAPER 84-2168)

The results of experimental studies of the aerodynamic characteristics of single-surface membrane wings constructed of inextensible flexible material are described and compared with theory. The experiments included measurement of the lift and drag characteristics of semispan wing models of three different planforms (triangular, parabolic, and elliptical). The wing surfaces were constructed of 2- and 4-mil stainless steel shim stock attached to a streamline leading-edge spar. This very thin metal membrane is flexible and adjusts its shape in response to the airflow over the wing surface. The experimental apparatus permitted variation of the camber and twist distribution of the wing. A unique method of describing the geometry of the wing is presented and used to correlate the experimental results and to compare experiment with theory. The experimental results agree well with lifting line theory below stall using the method presented for determining the geometric shape of the wing. The wing with the parabolic planform exhibited the best aerodynamic characteristics compared to the triangular and elliptical planforms. The maximum lift coefficients and lift-to-drag ratios measured are comparable to conventional rigid wings. Various dynamic phenomena encountered during the experiments are described. Author

**A86-32960*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EULER AND NAVIER-STOKES SOLUTIONS FOR FLOW OVER A CONICAL DELTA WING**

R. W. NEWSOME (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 552-561. Previously cited in issue 07, p. 837, Accession no. A85-19526. refs

**A86-32966#**

**COMPARATIVE STUDY BETWEEN TWO NAVIER-STOKES ALGORITHMS FOR TRANSONIC AIRFOILS**

M. R. VISBAL and J. S. SHANG (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 599-606. Previously cited in issue 07, p. 847, Accession no. A85-19777. refs

**A86-32978#**

**DYNAMIC STALL INCEPTION CORRELATION FOR AIRFOILS UNDERGOING CONSTANT PITCH RATE MOTIONS**

J. H. STRICKLAND and G. M. GRAHAM (Texas Tech University, Lubbock) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 678-680. Research supported by the Sandia National Laboratories. refs

(Contract F49620-82-C-0035)

Most of the experimental data obtained to date for unsteady separated flow over airfoils undergoing constant pitch rate motions have been obtained from oscillating airfoils undergoing relatively small sinusoidal pitch oscillations about a relatively low mean angle of attack. Attention is presently given to two tank flow visualizations in which a NACA 0015 airfoil was mounted on a carriage that imparted translational motion as well as constant rates of pitching about the quarter-chord. Hydrogen bubbles provided the flow visualizations, which appeared to be two-dimensional in character. Separation was noted to usually occur at the leading edge, at angles-of-attack that may greatly exceed the static stall angle. O.C.

**A86-32979#**

**SIMULATION OF INVISCID VORTEX-STRETCHED TURBULENT SHEAR-LAYER FLOW**

A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) and C. J. PURCELL (ETA Systems, Inc., St. Paul, MN) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 680-682.

Computational simulations are conducted for a vortex flowfield that develops when a delta wing meets an oncoming stream of air at a high angle-of-attack. If the Reynolds number of the flow is of the order of 10 million or larger, the shear stresses and dissipation terms take effect only in very thin layers of the flow on the surface of the wing and across the shear layers that separate from the leading and training edges. Attention is given to the dynamics and the stability of these free shear layers by means of numerical simulations that solve Euler equations with an artificial viscosity model. The flow is inviscid except across thin discontinuities like shock waves and vortex sheets. O.C.

**A86-32987*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**MACH REFLECTION AND AERODYNAMIC CHOKING IN TWO-DIMENSIONAL DUCTED FLOW**

A. KUMAR (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 695-697.

Flow through a two-dimensional duct with supersonic inflow is numerically investigated, from the viewpoint of the formation of Mach reflection, aerodynamic choking, and the possibility of constructing a curve similar to that for the quasi-one-dimensional flow in a converging-diverging duct. Such a curve can be used to determine whether a duct with a certain area ratio will or will not choke for a given inflow Mach number. Plots of pressure and mass flux contours are obtained for a given duct configuration. It is found that the two-dimensional flow always chokes at a higher Mach number than the corresponding quasi-one-dimensional flow for a given throat/inlet flow area ratio. O.C.

**A86-32989#**

**AIRFOIL DESIGN AT SONIC VELOCITY**

B. LING (Nanchang Aircraft Co., People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, March 1986, p. 1-10. In Chinese, with abstract in English. refs

A numerical finite difference method for calculating a hodograph solution at free-stream Mach number 1 is described. The exact hodograph formulation is used in the calculation. Because of the singularity of the far field boundary condition in the physical plane, which is mapped to a singular point on the hodograph plane, the approximate analytical solution of the Tricomi equation is employed. The boundary curves of five examples for the numerical calculations in the hodograph plane are described by the spline method. A family of airfoil shapes and their pressure distribution, drag, lift, and moment about the leading edge are presented. These sonic airfoil designs may be useful for assessing the near sonic aircraft performance. Author

**A86-32990#**

**THE PASSIVE CONTROL OF THE SHOCK WAVES ON TRANSONIC AIRFOILS**

G. SAVU (Aviation Institute, Bucharest, Rumania) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, March 1986, p. 11-18. refs

A method for the attenuation of shock waves on airfoils in supercritical flow is presented. By numerically solving the inviscid, small disturbance equation in steady transonic regime, with boundary conditions on solid or porous airfoils, the corresponding pressure distribution is obtained. Comparing the pressure distribution in both cases, one may observe that for the porous airfoils a gradually recompression towards the trailing edge is occuring, without strong shock waves, in a quite large Mach number domain, in opposition to the known fact that supercritical airfoil optimization is valid only in a very close vicinity of the design Mach number and incidence. For a given Mach number and incidence, the calculated pressure distribution on the airfoil having porous regions, is used to generate the contour of an equivalent solid airfoil whose shape resembles that of an supercritical airfoil. Author

**A86-32994#**

**AN IMPROVEMENT TO THE NUMERICAL METHOD FOR CALCULATIONS OF AIRCRAFT CONFIGURATION LONGITUDINAL AERODYNAMIC CHARACTERISTICS**

Z. JIANG (China Aerodynamic Research and Development Center, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, March 1986, p. 56-64. In Chinese, with abstract in English. refs

Based on the subsonic and supersonic potential theory, an improved numerical method is developed for the calculation of the surface pressure distribution on an aircraft and then the force and moment by integrating the pressure distributions, using surface distribution finite element solutions. With concepts of joint flow field and the effective section thrust and strip turbulent boundary layer theory, an improved drag calculation can be obtained. A computer program has been developed. Several examples of calculated aerodynamic characteristics are presented, and good agreement between calculation results and experimental data can be achieved. Author

**A86-33227*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### CALCULATION OF TRANSONIC STEADY AND OSCILLATORY PRESSURES ON A LOW ASPECT RATIO MODEL AND COMPARISON WITH EXPERIMENT

R. M. BENNETT, E. C. WYNNE (NASA, Langley Research Center, Hampton, VA), and D. G. MABEY (Royal Aircraft Establishment, Dynamics Laboratory, Bedford, England) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 1-16. Previously announced in STAR as N85-32092. refs

Pressure data measured by the British Royal Aircraft Establishment for the AGARD SMP tailplane are compared with results calculated using the transonic small perturbation code XTRAN3S. A brief description of the analysis is given and a recently developed finite difference grid is described. Results are presented for five steady and nine harmonically oscillating cases near zero angle of attack and for a range of subsonic and transonic Mach numbers. Author

**A86-33228**

### TRANSONIC EQUIVALENT STRIP METHOD FOR AEROELASTIC APPLICATIONS

D. D. LIU, Y. F. KAO (Arizona State University, Tempe), and K. Y. FUNG (Arizona, University, Tucson) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 17-32. Navy-supported research. refs

As an engineering tool for aeroelastic applications, the present Transonic Equivalent Strip (TES) method has established an efficient and cost-effective procedure for unsteady flow computations of arbitrary wing planforms including control surfaces. According to the nature of three-dimensional unsteady transonic flow, a method based on the TES model is developed which consists of two consecutive correction steps to a given unsteady two-dimensional code. The latter could be a time-linearized transonic code or a nonlinear one such as LTRAN2 code. First, the mean-flow correction step which involves an equivalent airfoil design procedure; second, the spanwise phase correction step which accounts for the effects of acoustic wave propagation in three dimensions. Computed results using the TES method are compared with those obtained by the current methods such as various versions of XTRAN3 code, Isogai's full potential code and measured data provided by NLR and by RAE. Computed cases include the Northrop F-5 wing in pitching oscillation, the AGARD standard RAE wing with an oscillating flap and the LANN wing in pitching oscillation. Assessments of the present approach and other existing methods will be given. Author

**A86-33229**

### CALCULATION OF 3-D UNSTEADY TRANSONIC POTENTIAL FLOWS BY A FIELD PANEL METHOD

R. VOSS (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 33-46. refs

A calculation method for 3-d transonic flows around oscillating wings is described. It solves the time-linearized unsteady transonic small perturbation equation by an integral equation method with a field panel technique. In a computer code called PTRAN3, the field panel technique is combined with a finite difference method. Accuracy and computer costs of the code are acceptable for routine flutter applications. Results are shown for applications to pitching motions of a rectangular wing and two swept wings (LANN wing and F5 wing) with high and low aspect ratio. Author

**A86-33230**

### APPLICATION OF TRANSONIC UNSTEADY METHODS FOR CALCULATION OF FLUTTER AIRLOADS

H. ZIMMERMANN and S. VOGEL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 47-61. refs

A supercritical airfoil profile is used as an example of the calculation of steady and unsteady pressure distributions by the application of different unsteady transonic codes; these primarily involve the nonlinear transonic small perturbation (TSP) equation and its time-linearized form, solved by time-marching as well as integral methods. The influence of the coefficient of the nonlinear term, the inclusion of the steady or quasi-steady boundary layer thickness, and the fulfilment of the Rankine-Hugoniot condition on the resulting pressure distribution, are all noted. The inclusion of the boundary layer led to a much larger shift in critical speed for the nonlinear TSP method than for its linearized version. O.C.

**A86-33231**

### EXACT CLOSED-FORM SOLUTIONS FOR NONLINEAR UNSTEADY TRANSONIC AERODYNAMICS

G. A. OYIBO (Fairchild Republic Co., Farmingdale, NY) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 71-79. refs

After establishing the existence of exact, closed form solutions for nonlinear unsteady aerodynamics, the full nonlinear unsteady velocity potential equations for an airfoil are considered and evidence for the ineffectiveness of traditional hodograph methods in solving these equations is presented. A mapping scheme is accordingly used to transform these full nonlinear equations into the hodograph plane; the resulting hodograph equations show that, by prescribing the Jacobian of the transformation ab initio, the exact closed form solutions can be obtained for the nonlinear unsteady aerodynamic characteristics of an airfoil in a potential flow. The shockless transonic results presented show trends that agree with the results of both previous investigators and the available experimental data. O.C.

**A86-33232*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### RECENT TRANSONIC UNSTEADY PRESSURE MEASUREMENTS AT THE NASA LANGLEY RESEARCH CENTER CENTER

M. C. SANDFORD, R. H. RICKETTS, and R. W. HESS (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 80-98. Previously announced in STAR as N85-23710. refs

Four semispan wing model configurations were studied in the Transonic Dynamics Tunnel (TDT). The first model had a clipped delta planform with a circular arc airfoil, the second model had a high aspect ratio planform with a supercritical airfoil, the third model has a rectangular planform with a supercritical airfoil and the fourth model had a high aspect ratio planform with a supercritical airfoil. To generate unsteady flow, the first and third models were equipped with pitch oscillation mechanisms and the first, second and fourth models were equipped with control surface oscillation mechanisms. The fourth model was similar in planform and airfoil shape to the second model, but it is the only one of the four models that has an elastic wing structure. The unsteady pressure studies of the four models are described and some typical results for each model are presented. Comparison of selected experimental data with analytical results also are included. Author

**A86-33233**

### STEADY AND UNSTEADY PRESSURE DISTRIBUTIONS ON VARIOUS PROFILES IN SEPARATED SUBSONIC AND TRANSONIC FLOW

H. TRIEBSTEIN (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 99-119. refs

Steady and unsteady aerodynamic data are obtained for three rectangular wings in two-dimensional flow. Low subsonic speed wind tunnel measurements were made on a wing with oscillating spoiler in pitch about its leading edge, where the airfoil profile was a supercritical MBB-Va2, while the high subsonic and transonic measurements were performed on pitching airfoils about the c/4-axis of both supercritical MBB-A3 and NACA 0012 profiles. The measurements were performed in order to arrive at systematic results with respect to Mach number, reduced frequency, incidence, and oscillation amplitude; these were then to be used in the development and assessment of subsonic and transonic codes. Emphasis is given to the higher harmonic parts of the unsteady pressure in the region of pressure jumps and flow separation. O.C.

**A86-33234**

### AN IMPROVED POTENTIAL GRADIENT METHOD FOR THE CALCULATION OF UNSTEADY AERODYNAMIC PRESSURES ON OSCILLATING WINGS IN SUPERSONIC FLOW

F.-Q. ZHANG and H. FOERSCHING (DFVLR, Aerodynamische Versuchsanstalt, Goettingen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 153-162. refs

A new computation method is presented to calculate unsteady aerodynamic pressure on oscillating wings in supersonic flow. The main feature of this method is the introduction and application of a new integral variable substitution, by which the computer time is reduced considerably together with an improvement of computation accuracy, especially for low supersonic Mach numbers and high reduced frequencies. Comparisons with other methods and experimental results show quits satisfactory agreement. Author

**A86-33235**

### AN EXACT FORMULATION OF THE UNSTEADY AERODYNAMIC THEORY OF LIFTING SURFACES UNDERGOING ARBITRARY SMALL MOTIONS IN A SUPERSONIC FLOW FIELD

L. LIBRESCU (Tel Aviv University, Israel) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 163-168. refs

This paper deals with the development of an exact algorithm allowing determination of the unsteady pressure field on 3D lifting surfaces undergoing arbitrary small motions in a supersonic flow field. The analysis starts with the linearized field equations of isentropic, inviscid compressible aerodynamics. Linearization of the relevant field equations is performed on the basis of the small-disturbance concept. In this framework each flow variable is represented as the superposition of a primary quantity, held to be constant and corresponding to the undisturbed conditions, and of a small-disturbance, stipulated to be an arbitrary time-dependent quantity. Author

**A86-33236**

### APPLICATION OF UNSTEADY WING COLLOCATION METHODS TO CASCADES IN SUBSONIC FLOW

A. KLOSE and B. LASCHKA (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 180-186. refs

The acceleration potential has been used to reformulate the integral equation relating pressure and downwash on the blades of cascades. In the present investigation harmonically oscillating blades in subsonic flow have been considered. A collocation method as used in lifting surface theories for single airfoils has been adapted to solve the cascade equation. Pressure distribution and airforces have been calculated for several values of stagger, reduced frequency, space-to-chord ratio, Mach number, and inter-blade phase angle. The results have been compared to those published in other reports and, in some cases, significant differences have been discovered. Author

**A86-33238*** California Univ., Los Angeles.

### A NEW LOOK AT ARBITRARY MOTION UNSTEADY AERODYNAMICS AND ITS APPLICATION TO ROTARY-WING AEROELASTICITY

P. P. FRIEDMANN (California, University, Los Angeles) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 194-210. refs

(Contract NAG2-209)

This paper presents in a unified manner recent research on arbitrary motion unsteady aerodynamics with an emphasis on applications to a number of rotary wing aeroelastic problems. The term arbitrary motion is used to denote growing or decaying oscillations with a certain frequency. The specific topics treated in this paper are: (1) generalization of Greenberg's theory and its application to hingeless rotor aeroelastic stability; (2) description of a new technique for formulating finite state approximations to unsteady aerodynamic theories, which are suitable for both fixed-wing and rotary-wing applications, and its application to generalize Loewy's theory; (3) comparison of fixed wing and rotary-wing indicial response functions; (4) influence of a arbitrary motion aerodynamics, as represented by dynamic inflow on a helicopter in ground resonance and (5) comparison of dynamic inflow with arbitrary motion unsteady airfoil aerodynamics. From the discussion of these topics a number of useful conclusions on the fundamental nature of arbitrary motion aerodynamics and its role in rotary-wing aeroelasticity are obtained. Author

**A86-33240**

### CALCULATION OF THE LOAD DISTRIBUTION, AERODYNAMIC DERIVATIVES AND DYNAMIC CHARACTERISTICS OF QUASI-STATIC ELASTIC AIRCRAFT

Q. LIU, C. WU, Z. JIAN, and K. WU (Northwestern Polytechnical University, Xian, People's Republic of China) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 219-228. refs

**A86-33408**

### STEADY TRANSONIC FLOW

E. DICK (Gent, Rijksuniversiteit, Ghent, Belgium) IN: Encyclopedia of fluid mechanics. Volume 1 . Houston, TX, Gulf Publishing Co., 1986, p. 510-532. refs

Steady flows in which some regions of the flow field are subsonic and other regions are supersonic are studied. Basic equations for the steady adiabatic flow of an inviscid fluid are derived, and some one-dimensional examples are treated. It is shown that a stationary compression shock can exist in a steady flow, and the relations between flow properties on both sides of the shock wave are analyzed. The flow in a convergent-divergent duct with a slowly varying S-section, such that the flow can be considered to be uniform in each section, is considered. Two-dimensional transonic flow is considered, including its general appearance, the effect of viscosity, transonic flow past an airfoil, transonic flow in cascades, and transonic shockless flow. The mathematical character of the Euler equations is analyzed, and the potential flow simplification is described. C.D.

**A86-33409**
**NUMERICAL MODELING OF TRANSONIC FLOWS OVER AIRFOILS AND CASCADES**
X.-H. ZHOU, S. L. LIU, and F.-D. FAN (Northwestern Polytechnical University, Xian, People's Republic of China) IN: Encyclopedia of fluid mechanics. Volume 1 . Houston, TX, Gulf Publishing Co., 1986, p. 533-559. refs

Numerical modeling of inviscid transonic flows around airfoils and in cascades is considered. The basic governing equations, computational mesh, discretization techniques for governing equations, boundary conditions, artificial dissipation, and methods of accelerating convergence are discussed. A time-dependent method for solving the Euler equations is stressed, discussing cascade flow computations in some detail. Some numerical results are presented to illustrate the accuracy and limitations of the numerical modeling. C.D.

**A86-33480**
**AERODYNAMICS AND MOLECULAR GAS DYNAMICS [AERODINAMIKA I MOLEKULIARNAIA GAZOVAIA DINAMIKA]**
V. V. STRUMINSKII Moscow, Izdatel'stvo Nauka, 1985, 240 p. In Russian. refs

A series of fundamental problems of practical interest in aerodynamics and molecular gasdynamics are treated using methods of the boundary layer theory and the kinetic theory of gases. Problems examined include the proof of the existence of the slip effect on rectangular wings of infinite aspect ratio and the conditions under which this effect is observed for wings with various degrees of sweep; the effect of acceleration on the structure of a boundary layer, its separation, and drag at low velocities; and the development of a nonlinear stability theory for plane laminar flows of a viscous liquid. Other problems discussed include the development of a more general method for solving Boltzmann equations and the development of a new nonequilibrium kinetic theory of gases. V.L.

**N86-22546** Virginia Polytechnic Inst. and State Univ., Blacksburg.
**ANALYSIS OF DYNAMIC STABILITY DERIVATIVES FOR HIGH ANGLE OF ATTACK AIRCRAFT Ph.D. Thesis**
J. S. KO 1985 184 p
Avail: Univ. Microfilms Order No. DA8521331

Modern, high performance aircraft are required to be able to fly and be controlled over a wide variety of flight conditions. In order to predict the aircraft behavior and control requirements over the entire flight regime it is necessary to have a proper aerodynamic model. In this research, wind tunnel experiments are performed on an F-5 aircraft model at high angles of attack, with small oscillations about the body oriented roll axis. In addition the free stream environment can be configured in one of three ways: (1) straight uniform flow, (2) curved flow to simulated a horizontal turn, and (3) rolling flow to simulated a roll motion about the relative velocity vector. A description of the wind tunnel velocity and the recently developed roll oscillatory rig is given. In addition new linearized equations of motion are developed for describing the small roll oscillation in the non-uniform flow environment. These equations are used to reduce the data obtained in the wind tunnel experiments in order to obtain the usual combined rotary and unsteady aerodynamic stability derivatives as well as new combinations of pure rotary derivatives obtainable only with the non-uniform flow conditions. Dissert. Abstr.

**N86-22548** California Univ., Los Angeles.
**UNSTEADY AERODYNAMICS IN TIME AND FREQUENCY DOMAINS FOR FINITE-TIME ARBITRARY MOTION OF HELICOPTER ROTOR BLADES IN HOVER AND FORWARD FLIGHT Ph.D. Thesis**
M. ASGHAR-HESSARI-DINYAVARI 1985 549 p
Avail: Univ. Microfilms Order No. DA8525824

Several incompressible finite-time arbitrary-motion airfoil theories suitable for coupled flag-lag-torsional aeroelastic analysis of helicopter rotors in hover and forward flight are derived. These theories include generalized Greenberg's theory, generalized Loewy's theory, and a staggered cascade theory. The generalized Greenberg's and staggered cascade theories were derived directly in Laplace domain considering the finite length of the wake and using operational methods. The load expressions are presented in the Laplace, frequency, and time domains. Approximate time domain loads for the various generalized theories are obtained by developing finite state models using Pade approximant of the appropriate lift deficiency functions. Three different methods for constructing Pade approximants of the lift deficiency functions were considered and the more flexible one was used. In the second part of this study the influence of finite-state arbitrary-motion time-domain aerodynamics on rotor blade aeroelastic stability was illustrated for hover and forward flight conditions. Dissert. Abstr.

**N86-22550*#** Boeing Commercial Airplane Co., Seattle, Wash.
**FLOW PREDICTION FOR PROPFAN ENGINE INSTALLATION EFFECTS ON TRANSPORT AIRCRAFT AT TRANSONIC SPEEDS Final Report**
S. S. SAMANT and N. J. YU Washington NASA Jan. 1986 93 p refs
(Contract NAS1-17250)
(NASA-CR-3954; NAS 1.26:3954) Avail: NTIS HC A05/MF A01 CSCL 01A

An Euler-based method for aerodynamic analysis of turboprop transport aircraft at transonic speeds has been developed. In this method, inviscid Euler equations are solved over surface-fitted grids constructed about aircraft configurations. Propeller effects are simulated by specifying sources of momentum and energy on an actuator disc located in place of the propeller. A stripwise boundary layer procedure is included to account for the viscous effects. A preliminary version of an approach to embed the exhaust plume within the global Euler solution has also been developed for more accurate treatment of the exhaust flow. The resulting system of programs is capable of handling wing-body-nacelle-propeller configurations. The propeller disks may be tractors or pushers and may represent single or counterrotation propellers. Results from analyses of three test cases of interest (a wing alone, a wing-body-nacelle model, and a wing-nacelle-endplate model) are presented. A user's manual for executing the system of computer programs with formats of various input files, sample job decks, and sample input files is provided in appendices. Author

**N86-22551#** National Aerospace Lab., Tokyo (Japan).
**NUMERICAL ANALYSIS OF INVISCID FLOWS ABOUT WING-FUSELAGE COMBINATIONS. PART 1: DEVELOPMENT OF GRID GENERATION CODE YOKUDO-G**
T. ISHIGURO, N. KAMIYA, and K. OGUCHI Jul. 1985 61 p refs In JAPANESE:ENGLISH summary
(NAL-TR-864; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

The main purpose of this paper is to numerically analyze inviscid flows about wing-fuselage combinations. In the first series a numerical procedure is presented for grind generation about a wing-fuselage combination by the analytic mapping method. A user's manual for the FORTRAN code of the procedure is also described. Furthermore, many numerical examples are presented in order to show the utility of this code for several wing-fuselage combinations and in order to understand the role of the controllable variables which yield many patterns of mesh distributions. In the next series, numerical analysis of inviscid flows will be carried out under the grids generated by this numerical procedure. Author

**N86-22552*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LOW-SPEED WIND-TUNNEL TESTS OF SINGLE- AND COUNTER-ROTATION PROPELLERS**

D. M. DUNHAM, G. L. GENTRY, JR., and P. L. COE, JR. Apr. 1986 46 p refs

(NASA-TM-87656; L-16077; NAS 1.15:87656) Avail: NTIS HC A03/MF A01 CSCL 01A

A low-speed (Mach 0 to 0.3) wind-tunnel investigation was conducted to determine the basic performance, force and moment characteristics, and flow-field velocities of single- and counter-rotation propellers. Compared with the eight-blade single-rotation propeller, a four- by four- (4 x 4) blade counter-rotation propeller with the same blade design produced substantially higher thrust coefficients for the same blade angles and advance ratios. The results further indicated that ingestion of the wake from a supporting pylon for a pusher configuration produced no significant change in the propeller thrust performance for either the single- or counter-rotation propellers. A two-component laser velocimeter (LV) system was used to make detailed measurements of the propeller flow fields. Results show increasing slipstream velocities with increasing blade angle and decreasing advance ratio. Flow-field measurements for the counter-rotation propeller show that the rear propeller turned the flow in the opposite direction from the front propeller and, therefore, could eliminate the swirl component of velocity, as would be expected. Author

**N86-22553*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF SOME GEOMETRIC VARIATIONS ON MISSILE AERODYNAMIC CHARACTERISTICS AT SUPERSONIC SPEEDS**

M. L. SPEARMAN Feb. 1986 26 p refs Presented at the 24th AIAA Aerospace Sciences Meeting, Reno, Nev., 6-9 Jan. 1986 Previously announced in IAA as A86-19958

(NASA-TM-87683; NAS 1.15:87683) Avail: NTIS HC A03/MF A01 CSCL 01A

A summary of some results from tests of a wing-body general research missile model is presented for a Mach number range up to 4.63. A basic ogive-cylinder body with a length-to-diameter ratio of 10 was used to which was attached a series of wing planforms. The planforms included a family of delta wings and a family of rectangular wings having a constant root chord but varying spans so that wings of constant exposed area could be compared. In addition, a cranked-tip planform was included and a rectangular planform with reduced chord. Some results are presented for wing-body-tail configurations - one utilizing a cranked wing planform and one with wings having a constant root chord and span, but tip chords that were 0, 20, and 40 percent of the root chord. Author

**N86-22554*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SUPERSONIC AXIAL-FORCE CHARACTERISTICS OF A RECTANGULAR-BOX CAVITY WITH VARIOUS LENGTH-TO-DEPTH RATIOS IN A FLAT PLATE**

A. B. BLAIR, JR. and R. L. STALLINGS, JR. Apr. 1986 21 p refs

(NASA-TM-87659; L-16075; NAS 1.15:87659) Avail: NTIS HC A02/MF A01 CSCL 01A

A wind-tunnel investigation has been conducted at Mach numbers of 1.50, 2.16, and 2.86 to obtain axial-force data on a metric rectangular-box cavity with various length-to-depth ratios. The model was tested at angles of attack from -4 deg to -2 deg. The results are summarized to show variations in cavity axial-force coefficient for deep- and shallow-cavity configurations with detached and attached cavity flow fields, respectively. The results of the investigation indicate that for a wide range of cavity lengths and depths, good correlations of the cavity axial-force coefficients (based on cavity rear-face area) are obtained when these coefficients are plotted as a function of cavity length-to-depth ratio. Abrupt increases in the cavity axial-force coefficients at an angle of attack of 0 deg. reflect the transition from an open (detached) cavity flow field to a closed (attached) cavity flow field. Cavity length-to-depth ratio is the dominant factor affecting the switching of the cavity flow field from one type to the other. The type of cavity flow field (open or closed) is not dependent on the test angles of attack except near the critical value of length-to-depth ratio. Author

**N86-22555#** Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.

**RANDOM-CHOICE-METHOD SOLUTIONS FOR TWO-DIMENSIONAL PLANAR AND AXISYMMETRIC STEADY SUPERSONIC FLOWS**

Z. C. SHI and J. J. GOTTLIEB Jan. 1986 98 p refs

(UTIAS-297; ISSN-0082-5255) Avail: NTIS HC A05/MF A01

A random-choice method (RCM) is developed for obtaining fairly practical and efficient numerical solutions for two-dimensional planar and axisymmetric steady supersonic flows, such as those for sharp-edged planar airfoils, supersonic inlets of aircraft engines, pointed bodies of revolution, supersonic nozzles, and free jets. This method is based on the solution of a Riemann problem, which is the elemental solution of the hyperbolic equations of two-dimensional steady supersonic flows. The Riemann problem consists of two waves separated by a slip stream, and each wave can be either an oblique shock wave or a Prandtly-Meyer expansion wave. Advanced techniques are given for solving the Riemann problem iteratively, handling the boundary conditions along body and free-jet surfaces, and computing only certain parts of flow fields of interest. Many interesting and practical numerical solutions are presented for different types of planar and axisymmetric flows, to demonstrate the applicability, capability, and limitations of the RCM. Numerical results are shown to be in excellent agreement with both known analytical solutions and results from the method of characteristics. Author

**N86-22556*#** Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics.

**VORTEX BOUNDARY-LAYER INTERACTIONS Semiannual Status Report, 1 Sep. 1985 - 31 Feb. 1986**

P. BRADSHAW 1986 14 p

(Contract NAGW-581)

(NASA-CR-176701; NAS 1.26:176701) Avail: NTIS HC A02/MF A01 CSCL 01A

Parametric studies to identify a vortex generator were completed. Data acquisition in the first chosen configuration, in which a longitudinal vortex pair generated by an isolated delta wing starts to merge with a turbulent boundary layer on a flat plate fairly close to the leading edge is nearly completed. Work on a delta-wing/flat-plate combination, consisting of a flow visualization and hot wire measurements taken with a computer controlled traverse gear and data logging system were completed. Data taking and analysis have continued, and sample results for another cross stream plane are presented. Available data include all mean velocity components, second order mean products of turbulent fluctuations, and third order mean products. Implementation of a faster data logging system was accomplished. bg

**N86-23559*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STATIC INVESTIGATION OF TWO STOL NOZZLE CONCEPTS WITH PITCH THRUST-VECTORING CAPABILITY**

M. L. MASON and J. R. BURLEY, II Apr. 1986 57 p refs

(NASA-TP-2559; L-165052; NAS 1.60:2559) Avail: NTIS HC A04/MF A01 CSCL 01A

A static investigation of the internal performance of two short take-off and landing (STOL) nozzle concepts with pitch thrust-vectoring capability has been conducted. An axisymmetric nozzle concept and a nonaxisymmetric nozzle concept were tested at dry and afterburning power settings. The axisymmetric concept consisted of a circular approach duct with a convergent-divergent nozzle. Pitch thrust vectoring was accomplished by vectoring the approach duct without changing the nozzle geometry. The nonaxisymmetric concept consisted of a two dimensional convergent-divergent nozzle. Pitch thrust vectoring was implemented by blocking the nozzle exit and deflecting a door in the lower nozzle flap. The test nozzle pressure ratio was varied up to 10.0, depending on model geometry. Results indicate that both pitch vectoring concepts produced resultant pitch vector angles which were nearly equal to the geometric pitch deflection angles. The axisymmetric nozzle concept had only small thrust losses at the largest pitch deflection angle of 70 deg., but the two-dimensional convergent-divergent nozzle concept had large performance losses at both of the two pitch deflection angles tested, 60 deg. and 70 deg. Author

**N86-23561*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMIC CHARACTERISTICS OF A SUPERSONIC FIGHTER AIRCRAFT MODEL AT MACH 0.40 TO 2.47**

F. J. CAPONE, E. A. BARE, and D. ARBITER (George Washington Univ., Hampton, Va.) Apr. 1986 105 p refs

(NASA-TP-2580; L-16017; NAS 1.60:2580) Avail: NTIS HC A06/MF A01 CSCL 01A

The aerodynamic characteristics of an advanced twin-engine fighter aircraft designed for supersonic cruise have been studied in the Langley 16-Foot Transonic Tunnel and the Lewis 10- by 10-Foot Supersonic Tunnel. The objective of this investigation was to establish an aerodynamic data base for the configuration with flow-through nacelles and representative inlets. The use of a canard for trim and the effects of fairing over the inlets were assessed. Comparisons between experimental and theoretical results were also made. The theoretical results were determined by using a potential vortex lift code for subsonic speeds and a linear aerodynamic code for supersonic speeds. This investigation was conducted at Mach numbers from 0.40 to 2.47, at angles of attack from 0 deg to about 20 deg, and at inlet capture ratios of about 0.5 to 1.4. Author

**N86-23562*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF UPPER-SURFACE NACELLES ON LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF HIGH-WING TRANSPORT CONFIGURATION**

L. E. PUTNAM Apr. 1986 70 p refs

(NASA-TP-2579; L-16062; NAS 1.60:2579) Avail: NTIS HC A04/MF A01 CSCL 01A

An investigation has been conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of installing and streamline contouring upper-surface nacelles on the longitudinal aerodynamic characteristics of a high-wing transport configuration. Also investigated were the effects of adding a fairing under the nacelle. The investigation was conducted at free-stream Mach numbers from 0.60 to 0.83 at angles fo attack from -2 deg to 4 deg. Flow-through nacelles were used. Streamline contouring the nacelles substantially reduced the interference drag due to installing the nacelles. Author

**N86-23565*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**USER'S GUIDE FOR NASCRIN: A VECTORIZED CODE FOR CALCULATING TWO-DIMENSIONAL SUPERSONIC INTERNAL FLOW FIELDS**

A. KUMAR Feb. 1984 70 p

(NASA-TM-85708; L-15678; NAS 1.15:85708) Avail: NTIS HC A04/MF A01 CSCL 01A

A computer program NASCRIN has been developed for analyzing two-dimensional flow fields in high-speed inlets. It solves the two-dimensional Euler or Navier-Stokes equations in conservation form by an explicit, two-step finite-difference method. An explicit-implicit method can also be used at the user's discretion for viscous flow calculations. For turbulent flow, an algebraic, two-layer eddy-viscosity model is used. The code is operational on the CDC CYBER 203 computer system and is highly vectorized to take full advantage of the vector-processing capability of the system. It is highly user oriented and is structured in such a way that for most supersonic flow problems, the user has to make only a few changes. Although the code is primarily written for supersonic internal flow, it can be used with suitable changes in the boundary conditions for a variety of other problems. Author

**N86-23566*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**LOCALLY LINEARIZED LONGITUDINAL AND LATERAL-DIRECTIONAL AERODYNAMIC STABILITY AND CONTROL DERIVATIES FOR THE X-29A AIRCRAFT**

G. D. BUDD Jan. 1984 480 p

(NASA-TM-84919; H-1203; NAS 1.26:84919) Avail: NTIS HC A21/MF A01 CSCL 01A

The locally linearized longitudinal and lateral-directional aerodynamic stability and control derivatives for the X-29A aircraft were calculated for altitudes ranging from sea level to 50,000 ft, Mach numbers from 0.2 to 1.5, and angles of attack from -5 deg to 25 deg. Several other parameters were also calculated, including aerodynamic force and moment coefficients, control face position, normal acceleration, static margin, and reference angle of attack. Author

**N86-23567*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**GEOMETRIC AND STRUCTURAL PROPERTIES OF A RECTANGULAR SUPERCRITICAL WING OSCILLATED IN PITCH FOR MEASUREMENT OF UNSTEADY TRANSONIC PRESSURE DISTRIBUTIONS**

R. H. RICKETTS, J. J. WATSON, M. C. SANDFORD, and D. A. SEIDEL Nov. 1983 19 p refs

(NASA-TM-85673; NAS 1.15:85673) Avail: NTIS HC A02/MF A01 CSCL 01A

Wind-tunnel tests to measure unsteady aerodynamic data in the transonic region have been completed on an aspect ratio 2.0 rectangular wing with a supercritical airfoil. The geometric and structural properties of the wing are presented. (Other references contain the measured aerodynamic data.) Both measured and design airfoil coordinates are presented and compared. In addition, measured wing bending and torsional stiffness distributions and some trailing-edge flexibility influence coefficients are presented. Author

**N86-23568*#** Analytical Methods, Inc., Redmond, Wash.

**INVESTIGATION TO ADVANCE PREDICTION TECHNIQUES OF THE LOW-SPEED AERODYNAMICS OF V/STOL AIRCRAFT**

B. MASKEW, D. STRASH, J. NATHMAN, and F. A. DVORAK Feb. 1985 153 p refs

(Contract NAS2-11169)

(NASA-CR-166479; NAS 1.26:166479) Avail: NTIS HC A08/MF A01 CSCL 01A

A computer program, VSAERO, has been applied to a number of V/STOL configurations with a view to advancing prediction techniques for the low-speed aerodynamic characteristics. The program couples a low-order panel method with surface streamline calculation and integral boundary layer procedures. The panel method--which uses piecewise constant source and doublet panels-includes an iterative procedure for wake shape and models boundary layer displacement effect using the source transpiration technique. Certain improvements to a basic vortex tube jet model were installed in the code prior to evaluation. Very promising results were obtained for surface pressures near a jet issuing at 90 deg from a flat plate. A solid core model was used in the initial part of the jet with a simple entrainment model. Preliminary representation of the downstream separation zone significantly improve the correlation. The program accurately predicted the pressure distribution inside the inlet on the Grumman 698-411 design at a range of flight conditions. Furthermore, coupled viscous/potential flow calculations gave very close correlation with experimentally determined operational boundaries dictated by the onset of separation inside the inlet. Experimentally observed degradation of these operational boundaries between nacelle-alone tests and tests on the full configuration were also indicated by the calculation. Application of the program to the General Dynamics

STOL fighter design were equally encouraging. Very close agreement was observed between experiment and calculation for the effects of power on pressure distribution, lift and lift curve slope. Author

**N86-23569*#** Rockwell International Science Center, Thousand Oaks, Calif.
**NONLINEAR POTENTIAL ANALYSIS TECHNIQUES FOR SUPERSONIC-HYPERSONIC AERODYNAMIC DESIGN**
V. SHANKAR and W. C. CLEVER 7 Mar. 1984 57 p refs
(NASA-CR-172299; NAS 1.26:172299) Avail: NTIS HC A04/MF A01 CSCL 01A

Approximate nonlinear inviscid theoretical techniques for predicting aerodynamic characteristics and surface pressures for relatively slender vehicles at supersonic and moderate hypersonic speeds were developed. Emphasis was placed on approaches that would be responsive to conceptual configuration design level of effort. Second order small disturbance and full potential theory was utilized to meet this objective. Numerical codes were developed for relatively general three dimensional geometries to evaluate the capability of the approximate equations of motion considered. Results from the computations indicate good agreement with experimental results for a variety of wing, body, and wing-body shapes. Author

**N86-23570#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**VALIDATION OF USAF STABILITY AND CONTROL DATCOM METHODOLOGIES FOR STRAIGHT-TAPERED SWEPTFORWARD WINGS Final Report, 1 Nov. 1980 - 30 Apr. 1984**
D. G. SHARPES Jul. 1985 211 p
(Contract AF PROJ. 2403)
(AD-A161876; AFWAL-TR-84-3084) Avail: NTIS HC A10/MF A01 CSCL 20D

A detailed review of USAF Stability and Control Datcom methodologies was conducted to determine their validity for application to straight tapered, sweptforward wing configurations. To the extent possible the format found in the Datcom is repeated in this report. Several methods were modified to enable more accurate coefficient prediction (e.g., Wing Zero-Lift Angle of Attack, Downwash and Yawing Moment due to Yaw Rate) irrespective of sweep sign. At supersonic speeds, the reversibility theorem enabled most methodologies to be used without any modifications to account for sweptforward leading-edge designs. For the methodologies validated, sweptforward-wing estimation results were generally as accurate as the sweptback-wing results presented in the Datcom. Unfortunately, lack of test data prevented validation of several empirical methodologies (e.g., Subsonic High Angle-of-Attack Pitching Moment and Transonic Pitching Moment). No estimation methodologies are proposed in these cases. Author (GRA)

**N86-23571#** Oklahoma Univ., Norman. School of Aerospace Mechanical and Nuclear Engineering.
**OPTIMIZATION OF TIP STORE MODELING Final Report, May 1983 - Sep. 1984**
A. G. STRIZ and S. K. JANG Mar. 1985 105 p
(Contract AF-AFOSR-0184-83)
(AD-A162119; AFOSR-85-1089TR) Avail: NTIS HC A06/MF A01 CSCL 20D

Due to the high cost of performing detailed three-dimensional flutter analyses for aircraft which are carrying large numbers and types of external stores, it is often not economically feasible to include sophisticated store aerodynamics especially when they will not cause significant changes to the flutter results. Thus, the stores are presently often modeled as simple flat plates. This tends to decrease the accuracy of the computed pressure distributions as the spanwise flow field and the wing-body interaction are not represented correctly. In this report, therefore, two methods, a doublet lattice method for subsonic flow and a kernel function method for subsonic and supersonic flow are used for the computation of unsteady pressure distributions and forces on an F-5 wing with a tip mounted launcher/store combination for various store models consisting of simple flat plates, endplated, and axisymmetric bodies. The resulting aerodynamic data are compared to existing experimental and numerical results for the same wing/store combination. The store modeling was optimized for simplicity and accuracy with respect to the aerodynamic forces and pressures. The wing-body interaction was improved without a considerable increase in complexity, i.e., panel number, and thus computational effort. Author (GRA)

**N86-23572#** Indiana Univ.-Purdue Univ., Indianapolis. School of Engineering and Technology.
**A ZONAL APPROACH TO THE DESIGN OF FINITE ELEMENT GRIDS FOR 3-D TRANSONIC FLOWS WITH COMPLEX GEOMETRIES Annual Report, 1 Jun. 1983 - 30 Jun. 1985**
A. ECER 30 Jun. 1985 98 p
(Contract F49620-83-K-0034)
(AD-A162168; AFOSR-85-1061TR) Avail: NTIS HC A05/MF A01 CSCL 20D

A block-structured solution scheme is developed for the analysis of three-dimensional transonic flows. The scheme is based on the solution of potential flow equations for individual blocks representing part of the flow field. Based on a previously developed block-structured grid generation scheme, appropriate computational grids are generated for each of the blocks depending on the complexity of the local flow field. The equations are then solved to provide a solution of a large problem in terms of an assembly of smaller problems for each block. Numerical results illustrate the applicability of the method for a three-dimensional flow field around a wing profile (NACA0012). Different block structures are analyzed to demonstrate the robustness and the accuracy of the developed method. Finally a three-dimensional wing-body configuration is analyzed and the results are compared with previously obtained single block solutions. The method is expandable to the solution of Euler and Navier-Stokes equations. It is also suited to be executed in a parallel processing environment. GRA

**N86-23573#** Boeing Commercial Airplane Co., Seattle, Wash.
**COUPLING LINEARIZED FAR-FIELD BOUNDARY CONDITIONS WITH NONLINEAR NEAR-FIELD SOLUTIONS IN TRANSONIC FLOW Annual Report, 1 Jul. 1983 - 1 Feb. 1985**
W. S. ROWE and F. E. EHLERS 1 Feb. 1985 82 p
(Contract F49620-83-C-0118)
(AD-A162334; D6-52895; AFOSR-85-1082TR) Avail: NTIS HC A05/MF A01 CSCL 20D

This investigation evaluated the feasibility of coupling linearized far-field finite differencing equations to reduce the size of grid networks required in present transonic flow calculations. A procedural change to an existing finite differencing program involved distributing sources on the solution interface boundary in order to develop the proper far-field outgoing wave boundary condition on a reduced size grid network. Validation of the modification procedure was established for zero thickness airfoils by comparing predicted two-dimensional results with results obtained from an exact procedure. A criterion based on the gradient of the flow field Mach number was developed for use in establishing the minimum size grid network necessary for accurate finite thickness unsteady loading predictions. Acceptable loading predictions were achieved for a nominal 5:1 gridsize reduction ratio with a 40% reduction in computer usage costs. GRA

**N86-23575#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**ACTA AERODYNAMICA SINICA (SELECTED ARTICLES)**
F. ZHUANG, H. ZHANG, G. LING, S. XIUNG, and P. ZHU 5 Dec. 1985 182 p Transl. into ENGLISH from Konggi Donglixue Xuebao (China), no. 4, 1984 p 1-4; 21-33; 41-97
(AD-A162993; FTD-ID(RS)T-0639-85) Avail: NTIS HC A09/MF A01 CSCL 20D

Titles include: Advances in the Study of Separated Flows; Problems in Discrete Vortex Numerical Modelling of Vortex Motion behind a Circular Cylinder; Calculation of Slender Delta Wing with

Leading-edge Separation by Quasi-vortex-lattice Method; Calculation of Flow around Thick Wing with Separation Vortices; Split Coefficient Matrix Difference Method for Supersonic Three-dimensional Flow; Some Characteristics of the FLIC Method and Its Application to Calculation of Pitot Pressure of Dusty-Gas Shock Tube Flow; Experimental Investigation of Flap Turbulent Heat Transfer and Pressure Characteristics in Hypersonic Flow; Laser Doppler Anemometer Measurements for Leading Edge Vortex Core Velocity of a Strake-wing; Experimental Research of Boundary Layer Control Technique for Low Speed Multi-component Airfoils; A Simpler Implicit Method to Solve N-S Equation; Numerical Calculation of Separation Flow over Severely Indented Blunt Body; Implicit Technique for Calculating Separated Base Flow; Computation of Compressible Turbulent Separated Boundary Layer; Inverse Boundary Layer Method for Separated Flow; Wall Lift Interference Corrections in Ground Effect Testing. (Translations; China; Chinese language) GRA

**N86-23576#** Technische Hochschule, Darmstadt (West Germany). Fachgebeit Aerodynamik und Messtechnik.

**INVESTIGATIONS IN THE FLOW FIELD OF AIRFOILS WITH VARIOUS GEOMETRIES IN THE DOMAIN OF HIGH ANGLES OF ATTACK. EXPERIMENTAL INVESTIGATIONS Final Report [UNTERSUCHUNGEN IM STROEMUNGSFELD VON FLUEGELN VERSCHIEDENER GEOMETRIE IM HOHEN ANSTELLWINKELBEREICH. EXPERIMENTELLE UNTERSUCHUNGEN]**

W. MOELLER 2 Sep. 1985 111 p refs In GERMAN
(Contract DFG-HA-514/63-2)
(REPT-A-13/85) Avail: NTIS HC A06/MF A01

A measuring system to determine flow fields of airfoils was developed. Pressure distribution measurements and pictures were taken to characterize all flight conditions in the domain of high angles of attack where flow separation phenomena are very important. The developed direct flow field measuring system uses hot-wire anemometry and enables the investigation of three-dimensional separation effects on an arrow wing. The results provide important information about the separation behavior of such wings and fundamentals for the development and testing of theoretical methods to calculate separated wing flow. Author (ESA)

**N86-23862#** Tokyo Univ. (Japan).

**NUMERICAL SIMULATION OF VORTICES SHED BEHIND A ROTATING WING**

N. IZUTSU and H. KANDA (IBM Japan, Ltd.) *In its* Proceedings of the Symposium on Mechanics for Space Flight p 43-50 Mar. 1985 refs Sponsored in part by IBM Japan, Ltd.
Avail: NTIS HC A08/MF A01

The vortices shed behind a 15%-thick, two dimensional elliptic cylinder rotating around its spanwise axis perpendicularly to a uniform flow were numerically analyzed using discrete vortex-blob method. The color coded vorticity distributions in the flow field were displayed in both cases of the forced and autorotation. Moreover, a 16 mm animation movie of it was made to visualize vortex interactions. By means of this color graphic simulation, the merging rearrangement, interaction and splitting of the vortices in the wake flow of a rotating wing were demonstrated making these processes clearly understandable. Author

# 03

# AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-29872#**

**CONTROLLED-FLIGHT-INTO-TERRAIN ACCIDENTS DURING UNPUBLISHED-ROUTE RADAR VECTORING**

J. M. MCCORMICK, JR. (Air Line Pilots Association, Washington, DC) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 199-206. refs

The present paper is concerned with Controlled-Flight-Into-Terrain (CFIT) accidents involving aircraft operated under Instrument Flight Rules (IFR) in controlled airspace, taking into account Instrument Meteorological Conditions (IMC) and Night Visual Meteorological Conditions (NVMC). As an example for the type of accident being considered, an event is described in which an instrument flight instructor and her student in a single-engine Cessna aircraft impacted mountainous terrain at the 3500-foot level. Attention is given to the guidance of the aircraft with the aid of 'radar vectors', the loss of voice communication between controller and aircraft, and questions concerning a situation which made a flight of five minutes duration in the clouds toward high terrain by an experienced flight instructor possible. It is found that problems can arise because pilots are routinely guided over unpublished 'radar routes'. Interim and long-term solutions to these problems are discussed. G.R.

**A86-29936#**

**AIR TRANSPORT PILOT INVOLVEMENT IN GENERAL AVIATION ACCIDENTS**

S. SALVATORE, S. HUNTLEY, and P. MENGERT (DOT, Transportation Systems Center, Cambridge, MA) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 729-739.

The involvement of airline transport pilots (ATPs) and private pilots (PVTs) flying general aviation (GA) aircraft in fatal and nonfatal accidents is investigated. Accident records for GA accidents occurring between 1973-1983 are studied; the data indicate that PVTs were involved in 13,219 nonfatal and 2,454 fatal accidents, and ATPs produced 461 nonfatal and 96 fatal accidents. Analysis of the data reveals that the ATPs comprise 7.5 percent of pilots, but account for only 3 percent of GA accidents while having greater exposure time than PVTs. Accident characteristics, causes, and pilot behaviors which differentiate the two groups are described. It is concluded that ATPs are involved in less GA pilot-induced accidents, less weather-related accidents, and less accidents in traffic patterns than PVTs due to their superior flying skills. I.F.

**A86-30097**

**INVESTIGATION OF AN AIRCRAFT ACCIDENT BY FRACTOGRAPHIC ANALYSIS**

R. V. KRISHNAN, S. RADHAKRISHNAN, A. C. RAGHURAM, and V. RAMACHANDRAN (National Aeronautical Laboratory, Bangalore, India) IN: Advances in fracture research (Fracture 84). Volume 5 . Oxford and New York, Pergamon Press, 1986, p. 3677-3684. refs

A Boeing 737 passenger aircraft suffered a mid-air explosion in the front toilet area during a scheduled flight and forced the pilot to make an emergency landing. In that process the aircraft overshot the runway damaging its undercarriage and underside. To determine the primary cause of explosion and its exact location, extensive fractographic examination was carried out on the fragments found near the explosion area. These fragments contained signatures characteristic of explosive fracture. The exact location of these fragments in the original aircraft structure was identified. It was concluded that the accident was due to a chemical explosion inside the front toilet of the aircraft. By tracing the trajectories of the projectiles flying in various directions following the explosion, the centre of the explosion, i.e., the location of the explosive device in the aircraft was established to be the waste paper receptacle placed under the wash basin. Author

**A86-31005#**
**SURVIVAL OF HELICOPTER ACCIDENTS [SUPERVIVENCIA EN LOS ACCIDENTES DE HELICOPTEROS]**
J. A. ROJAS LOZANO (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Oct. 1985, p. 31-36. In Spanish. refs

An evaluation is made of anthropometric factors relevant to the improvement of helicopter crash injury rates, in view of a U.S. Army study of helicopter crashes occurring in 1970-1971 which estimated that as many as 160 fatalities could have been prevented with suitable attention by designers to crash survival criteria. Attention is given to the capacity of the human body for absorption of the impact loads of sudden deceleration; data are presented for the effects of harnesses and the duration and magnitude limits of human resistance to injury by sudden deceleration. O.C.

**A86-31011#**
**ACCIDENT OF THE DC-10 EC-DEG AIRCRAFT AT MALAGA ON SEPTEMBER 13, 1982 [ACCIDENTE DEL AVION DC-10 EC-DEG EN MALAGA EL 13 DE SEPTIEMBRE DE 1982]**
IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Jan. 1986, p. 24-31. In Spanish.

The present analysis of the abortive takeoff-type accident of a DC-10 at Malaga airport gives attention to the velocity profiles of the aircraft from takeoff to ground impact. A fire followed ground impact. Takeoff abort was initiated by the crew with only 1295 m of runway left beneath the aircraft. On the basis of the data obtained by this analysis, it is recommended that both pilots and other flight crew members be trained to respond to takeoff failures due to causes other than loss of engine power, such as landing gear collapse. O.C.

**A86-31324**
**THE ECONOMICS OF THE NORTH ATLANTIC AIR TRAFFIC SYSTEM**
V. W. ATTWOOLL Journal of Navigation (ISSN 0020-3009), vol. 39, Jan. 1986, p. 103-109.

The effects of the meteorological environment and navigational restrictions on the North Atlantic air traffic system are investigated. The use of 12-hour and 24-hour forecasts to plan the proper organized track structure for aircraft to follow over the Atlantic is discussed. Inaccurate forecasting influences the fuel consumption and arrival times of the aircraft. The penalties that result from separation minima imposed by the air traffic control, which are 60 n.m. laterally and 2000 ft vertically, are examined; these limitations cause changes in flight plans and do not permit the optimum performance of the aircraft. Methods of improving the North Atlantic air traffic system, including the use of a composite track system, a reduction in vertical separation form 2000 ft to 1000 ft, and the use of later and more accurate weather forecasts, are described. I.F.

**A86-31325**
**AIRLINES AND THE NEW TECHNOLOGY AIRCRAFT - A DISCUSSION PAPER**
G. A. C. GRAY (British Airways, PLC, Hounslow, England) Journal of Navigation (ISSN 0020-3009), vol. 39, Jan. 1986, p. 110-119.

Advances in aircraft technology and crew training procedures are studied. The configuration of the flight deck, new flight instruments and displays, and crew procedures for the new aircraft are described. The required interactions between air traffic control and the flight crew in order to assure the optimum performance of the aircraft are examined. The use of audio visual tutors and flight simulator to train the pilots on the functions of electronic flight instrumentation, automatic flight control, and flight management computers is investigated. The advantages and disadvantages of the digital computation systems are analyzed. Future developments in avionics such as a comprehensive data-link network are discussed. I.F.

**A86-31956#**
**ANATOMY OF A NOISE-ABATEMENT CLIMB**
M. A. GARBELL (M.A.G. Consultants, Inc., San Francisco, CA) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 1 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 311-314. refs

Noise abatement aircraft climb techniques for the first 10-12 nautical miles of flight are discussed. The basic prerequisites for a safe and efficient climb are reviewed, and the factors controlling the intensity of noise emission at a point on the ground are described along with the standard types of noise-abatement climbs. The effect of meteorological parameters on aircraft noise is summarized, and the quality of the currently available data base on climb procedures and noise abatement is assessed. C.D.

**A86-32068**
**BIODYNAMICS OF PERSONNEL PARACHUTE LANDINGS - A FRESH LOOK AT PARACHUTE DESCENT RATES**
D. C. JOHANSON and K. E. WITTENDORFER (U.S. Navy, Naval Weapons Center, China Lake, CA) SAFE Journal, vol. 16, Spring 1986, p. 16-23.

A test program has been established to provide biodynamic data of simulated parachute landings which, when combined with biomechanical data and a computer model, will indicate the safety of various combinations of total speed and angle of impact. This information will then provide more substantial justification into the maximum acceptable velocities for specifications such as MIL-P-85710 and MIL-S-18471. Test facility components include a 59-foot rail assembly which can be adjusted to assume angles from the vertical to the horizontal, a jumper connected to a launch vehicle via a parachute harness and risers, and a velocity-measuring gravity-assisted pulley control system. After obtaining specified steady-state conditions, the subject performs a forward right plf upon ground contact. Data displayed reduced g levels in the four-foot plf, in comparison with a four-foot standup landing, supporting the advantages in performing a plf. Time-dependent quantities of acceleration, delta velocity, body angle, and angulalr rate were plotted, and a viable method of determining relationships between the impact velocity vector and transducer signals has been found. K.K.

**A86-32070**
**EVALUATION OF THE CRASH ENVIRONMENT AND INJURY-CAUSING HAZARDS IN U.S. NAVY HELICOPTERS**
J. W. COLTMAN, S. ARNDT (Simula, Inc., Phoenix, AZ), and L. DOMZALSKI (U.S. Navy, Naval Air Development Center, Warminster, PA) SAFE Journal, vol. 16, Spring 1986, p. 44-50. refs

A survey of the crash environment for U.S. Navy helicopters was undertaken to quantify the impact parameters and identify hazards causing major injury. One hundred and eighty-six (186) Flight Mishaps were reviewed for the 10-year period of January 1972 to December 1981. Out of the 186 mishaps reviewed, 154 were judged to be survivable. Accident reconstruction was used to determine the impact parameters for the survivable accidents. Statistical distribution of the important impact parameters, such as pitch, roll, and yaw angle and vertical, horizontal and lateral velocity change, were developed. Also, a hazard analysis was conducted to correlate the major and fatal injuries to the injury-causing hazards mechanisms. Sixteen specific injury-causing hazards were identified. The data developed in this study provides the basis for improving the crashworthiness of the existing helicopter fleet and of future Navy aircraft. Author

**A86-33427**
**MAJOR SHORT-HAUL ROLE SEEN FOR TILT-ROTOR AIRCRAFT**
R. F. SPIVEY (Bell Helicopter Textron, Fort Worth, TX) ICAO Bulletin, vol. 41, Feb. 1986, p. 25-28.

An evaluation is made of the prospective impact of tilt-rotor aircraft VTOL operations, in the air taxy and city center-to-city center commuter fields, on airport congestion. The tilt rotor VTOL aircraft envisioned in these performance evaluations is a civilian version of the U.S. Armed Forces' 'JVX', which is in turn a scale-up development of the XV-15 test aircraft. Emphasis is given to the ability of a tilt-rotor aircraft in its commuter airliner function to bypass regional airports and deliver passengers to city centers directly. O.C.

**N86-22558*#** Ohio State Univ., Columbus. Aeronautical and Astronautical Research Lab.
**WIND TUNNEL TESTS OF ROTOR BLADE SECTIONS WITH REPLICATIONS OF ICE FORMATIONS ACCRETED IN HOVER Final Report**
J. D. LEE, J. H. BERGER (Fluidyne Engineering Corp., Columbus, Ohio), and T. J. MCDONALD (Fluidyne Engineering Corp., Columbus, Ohio) Mar. 1986 31 p refs
(Contract NAG3-374)
(NASA-CR-175089; NAS 1.26:175089) Avail: NTIS HC A03/MF A01 CSCL 01C

Full scale reproductions of ice accretions molded during the documentation of a hover test program were fabricated by means of epoxy castings and used for a wind tunnel test program. Surface static pressure distributions were recorded and used to evaluate lift and pitching moment increments while drag was determined by wake surveys. Through the range of the tests, corresponding to those conditions encountered in hover and in flat pitch, integration of the pressure distributions showed negligible changes in lift and in pitching moment, but the drag was significantly increased. Author

**N86-22559*#** Fluidyne Engineering Corp., Columbus, Ohio.
**DOCUMENTATION OF ICE SHAPES ACCRETED ON THE MAIN ROTOR OF A UH-1H HELICOPTER IN LEVEL FLIGHT Final Report**
M. K. HANSON and J. D. LEE (Ohio State Univ., Columbus) Mar. 1986 14 p refs
(Contract NAG3-374)
(NASA-CR-175088; NAS 1.26:175088) Avail: NTIS HC A02/MF A01 CSCL 01C

Icing tests were conducted on a UH-1H helicopter in level flight behind a spray tanker near Duluth, Minnesota, during the winter of 1983-84 as part of the joint NASA/Army HIFT program. On landing, the ice formations on the main rotor were documented by casting a set of ten-inch molds on the blade using a Dow-Corning silicone rubber compound which was initially liquid at sub-freezing temperatures. Such documentation was accomplished for eight flights in which the temperature ranged from -11 C to -22 C and the in-cloud flight times ranged from 5 to 9 minutes. Author

**N86-22560#** Aeronautical Research Labs., Melbourne (Australia).
**THE AUSTRALIAN IMPLEMENTATION OF AMDAR/ACARS AND THE USE OF DERIVED EQUIVALENT GUST VELOCITY AS A TURBULENCE INDICATOR**
D. J. SHERMAN Oct. 1985 42 p refs
(AR-004-51; ARL-STRUC-R-418) Avail: NTIS HC A03/MF A01

AMDAR is a system of measuring wind speed, wind direction, air temperature and an indication of turbulence from INS equipped transport aircraft in flight. These data are transmitted by radio to the meteorological system. This report outlines the Australian AMDAR system presently coming into service on the Boeing 767 aircraft in the Ansett fleet. The data are telemetered using ACARS and the SITA/AIRCOM network of ground stations. Particular attention is paid to the indicator of turbulence. Because an aircraft flying through a given gust may encounter very different vertical accelerations depending on aircraft mass, airspeed and altitude, it is proposed that the AMDAR system compute the derived equivalent gust velocity from the aircraft acceleration and other parameters, and that this is used as an indicator of turbulence. Such an indicator has the additional advantage that it is more use for climatological studies of turbulence occurrence than simpler indicators such as the aircraft vertical acceleration. Severe turbulence corresponds to derived equivalent gust velocities in excess of g m/s. Author

**N86-23577*#** Sverdrup Technology, Inc., Cleveland, Ohio.
**ANALYTICAL DETERMINATION OF PROPELLER PERFORMANCE DEGRADATION DUE TO ICE ACCRETION Final Report**
T. L. MILLER Apr. 1986 138 p refs
(Contract NAS3-24105)
(NASA-CR-175092; NAS 1.26:175092) Avail: NTIS HC A07/MF A01 CSCL 01C

A computer code has been developed which is capable of computing propeller performance for clean, glaze, or rime iced propeller configurations, thereby providing a mechanism for determining the degree of performance degradation which results from a given icing encounter. The inviscid, incompressible flow field at each specified propeller radial location is first computed using the Theodorsen transformation method of conformal mapping. A droplet trajectory computation then calculates droplet impingement points and airfoil collection efficiency for each radial location, at which point several user-selectable empirical correlations are available for determining the aerodynamic penalities which arise due to the ice accretion. Propeller performance is finally computed using strip analysis for either the clean or iced propeller. In the iced mode, the differential thrust and torque coefficient equations are modified by the drag and lift coefficient increments due to ice to obtain the appropriate iced values. Comparison with available experimental propeller icing data shows good agreement in several cases. The code's capability to properly predict iced thrust coefficient, power coefficient, and propeller efficiency is shown to be dependent on the choice of empirical correlation employed as well as proper specification of radial icing extent. Author

**N86-23578#** Luftfahrt-Bundesamt, Brunswick (West Germany). Flugunfalluntersuchungsstelle.
**RESULTS OF THE TECHNICAL INVESTIGATION OF ACCIDENTS DURING THE OPERATION OF GERMAN AIRCRAFT AT HOME AND ABROAD, AND OF FOREIGN AIRCRAFT IN GERMANY Annual Report, 1982 [ERGEBNISSE DER FACHLICHEN UNTERSUCHUNG VON UNFAELLEN BEI DEM BETRIEB DEUTSCHER LUFTFAHRZEUGE IM IN- UND AUSLAND SOWIE AUSLAENDISCHE LUFTFAHRZEUGE IM INLAND]**
Jul. 1985 119 p In GERMAN
Avail: NTIS HC A06/MF A01

All aircraft accidents since January 1, 1973 were analyzed. Standardized tables giving a general overview are presented. Special statistics can be provided, for which selection criteria and table parameters can be freely chosen. Author (ESA)

# 04

# AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-30314#**

**FLIGHT TEST OF A VELOCITY AUGMENTED STRAPDOWN NAVIGATION SYSTEM LHN-81**

H.-J. HOTOP, H.-P. ZENZ (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany), and M. KLEINSCHMIDT (LITEF-Litton Technische Werke, Freiburg im Breisgau, West Germany) IN: Symposium Gyro Technology 1985; Proceedings of the Symposium, Stuttgart, West Germany, September 24, 25, 1985 . Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1985, p. 16.0-16.21. refs

Helicopter-based flight tests have been conducted for the LHN-81 hybrid navigation system, which is of the inertial strapdown type and is augmented by a Doppler velocity sensor and a magnetic heading sensor; performance comparisons have been made with the existing LTN-90 inertial navigation system, whose accuracy had been increased by means of an offline algorithm. The position accuracy of the LHN-81 is 1.3 percent in 95 percent of all events. For a nap-of-the-earth flight profile with helicopter dynamics, the 95-percent CEP accuracy in 15 min of flight time was less than 100 m. O.C.

**A86-30358**

**GRAPHIC SIMULATION FOR AIR TRAFFIC CONTROL DEVELOPMENT**

E. S. STEIN (FAA Technical Center, Atlantic City, NJ) IN: 1985 Summer Computer Simulation Conference, Chicago, IL, July 22-24, 1985, Proceedings . San Diego, CA, Society for Computer Simulation, 1985, p. 653-656. refs

In air traffic control, graphic simulation means employing equipment currently available to provide a two-dimensional representation of the three-dimensional airspace using a preplanned 'canned' air traffic scenario. The background history of the use of graphic simulation in aviation is examined, taking into account the use of situational graphics to evaluate potential pilots' abilities to relate aircraft orientation to instrument displays. In developments toward higher levels of automation, one family of tools is AERA, the automated en route air traffic control program. Aspects of AERA graphic simulation are examined, giving attention to the problem, the laboratory, the flight data display, the radar planned view display, and an overview of the graphic simulation. The employment of graphic simulation is also discussed. G.R.

**A86-30488**

**KNOWLEDGE-BASED APPROACH TOWARD DEVELOPING AN AUTONOMOUS HELICOPTER SYSTEM**

J. F. GILMORE and A. C. SEMECO (Georgia Institute of Technology, Atlanta) Optical Engineering (ISSN 0091-3286), vol. 25, March 1986, p. 415-427. Research supported by the Georgia Institute of Technology. refs

This paper presents a description of the Autonomous Helicopter System (AHS) which is currently being implemented in the Georgia Tech Research Institute. It is pointed out that autonomous vehicles provide a mechanism for removing humans from modern-day battlefields while not impacting the tactical capabilities of the battle force. Civilian applications for such a device include the investigation of hazardous areas, search over large areas, and the monitoring of large facilities. The AHS consists of three sections. The vision section is the sensor processing component of the AHS. Attention is given to image segmentation, region classification, scene analysis, visual model construction, scene matching, and threat location and coverage. The goal of the planning section is to produce an executable plan of action which can be implemented by the control section. The goal of the control section is also discussed, and an autonomous helicopter mission is described. G.R.

**A86-31004#**

**THE PRIVATE ENTERPRISE FACTOR IN REGIONAL AIRLINES [LA GESTION EMPRESARIAL EN LAS CIAS - AEREAS DE TERCER NIVEL]**

R. FERNANDEZ (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Aug.-Sept. 1985, p. 9-20. In Spanish.

An economic and regulatory evaluation is made of the prospects for Spanish regional airlines, with reference to such factors as competition, political climate, aircraft acquisition and maintenance costs, personnel management, and direct and indirect cost structures. Extensive comparisons are made with similar operations in the U.S. and Europe. The importance of debt structures in the financing of such airline operations is emphasized. O.C.

**A86-31006#**

**AERIAL NAVIGATION [NAVEGACION AEREA]**

E. MUNOZ DE LUNA (Direccion General de Aviacion Civil, Centro de Control de Sevilla, Seville, Spain) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Nov. 1985, p. 12-21. In Spanish.

The development status and organizational structure of Spain's ATC system are discussed, with attention to the degree and effectiveness of ATC automation. The features and capabilities of communications, surveillance radar, and navigation aids subsystems are noted. The Spanish ATC system's primary installations are at Paracuellos, Barcelona, Palma, Las Palmas, and Sevilla. Modernization efforts currently underway and planned are identified. O.C.

**A86-31007#**

**CONSIDERATIONS ON THE INFLUENCE OF POSITIONING ON THE QUALITY OF GP ILS INFORMATION [CONSIDERACIONES SOBRE LA INFLUENCIA DEL EMPLAZAMIENTO EN LA CALIDAD DE LA INFORMACION GP ILS]**

E. LALLEMAND IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Nov. 1985, p. 29-33. In Spanish.

A ground position instrument landing system (GP ILS) radiates horizontal polarization energy signals at 329.3-335.0 MHz in order to furnish elevation data to aircraft during landing approaches. This signal determines the modulation amplitude of two audible tones over the UHF channel. The consequences for this ILS data of the position (spatial distribution) of the signals is presently treated in light of the Fresnel zones created by this system's antennas. O.C.

**A86-31008#**

**TRENDS IN THE DESIGN OF AIRFIELD RADARS [TENDENCIAS EN EL DISENO DE RADAR PARA AERODROMOS]**

D. J. SIMMONS (Plessey Co., PLC, Ilford, England) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Nov. 1985, p. 35-42. In Spanish.

Attention is given to the radar system requirements of civilian and military airfields, with emphasis on the spurious effects of background clutter radar echoes generated by terrain, rain, etc. A performance comparison is made between magnetron, klystron, and traveling wave tube S-band radar designs with respect to such factors as pulse compression capability, sector suppression, stability, operational flexibility, and peak power. A detailed discussion is presented of the performance of the 'Watchman' primary radar. O.C.

**A86-31009#**

**RESTRICTIONS ON THE DISPOSITIONS OF NAVIGATION AIDS [RESTRICCIONES EN EL ENTORNO DE LAS AYUDAS A LA NAVEGACION]**

R. BENITEZ IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Dec. 1985, p. 9-15. In Spanish.

Restrictions on the positioning and radiation pattern of such airport approach navigation aids as the microwave landing system (MLS) and older ILSs are undertaken in order to safeguard their radiation patterns, without obstruction of their radiation energy, thereby maximizing airport security, reliability of operations, and efficiency. A detailed discussion is presented concerning navigation aid antenna placement, aircraft landing approach relationships to navigation aid coverage, and a projected schedule for the transition from ILS systems to the state-of-the-art MLS. O.C.

**A86-31323**

**NAVIGATION IN AERIAL COMMERCE**

J. E. D. WILLIAMS (Institute of Navigation, Annual General Meeting, 39th, London, England, Oct. 23, 1985) Journal of Navigation (ISSN 0020-3009), vol. 39, Jan. 1986, p. 1-16. refs

Developments in air navigation are reviewed. The objectives of navigation are quickness, regularity, fuel conservation, low wear and tear, maximum payload, comfort, safety, and noise abatement. The advances in navigation technique from average drift path, to altimeter flying, and to the present inertial navigation systems are described and examples are provided. The limitations on navigation imposed by air traffic control in order to insure safety, and the need to have a unified management for air traffic control are examined. I.F.

**A86-32078#**

**INSTRUMENTATION SYSTEM FOR REAL TIME NAVIGATION SYSTEM PERFORMANCE ASSESSMENT**

G. LUI-KWAN (Boeing Military Airplane Co., Seattle, WA) and D. E. ATKINSON (USAF, Wright-Patterson AFB, OH) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9731)

The Navigation Accuracy Instrumentation System (NAIS) was designed as a real time navigation instrumentation system for the evaluation of the B-1B aircraft's navigation suite performance. Differences in position and velocity between NAIS and the Inertial Navigation Units aboard the B-1B are provided to the operator for in-flight evaluation of the navigation system's performance. These data are also recorded for postflight evaluation of test flights. Attention is given to the role of NAIS in the evaluation of the B-1B Navigation and Weapons Delivery system performance. O.C.

**A86-32080#**

**FLIGHT PATH MEASUREMENT OF HELICOPTERS USING A STRAP-DOWN NAVIGATION SYSTEM**

H. GLOECKL and A. GRUENEWALD (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9733)

A strapdown navigation system is developed to measure helicopter flight path for flight certification at any location and without the use of special ground equipment. The required accuracy is achieved through high accuracy sensors, which help minimize acceleration errors, and the avoidance of unnecessary flight maneuvers in flights limited to two minutes. Measurements of attitude, velocity, distance, and altitude were made for translatory movements, Cat A and B start and landing profiles, H/V tests (upper point and knee point), and Cat A vertical takeoff profiles from a platform. Instantaneous measurement accuracy checking is possible at the end of each test. R.R.

**A86-32127#**

**F-16 RADAR DATA ACQUISITION AND ANALYSIS**

S. G. DI DOMENICO (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 6 p.
(AIAA PAPER 86-9798)

A system for the quick turn around of F-16 AN/PG-68 Doppler radar data for qualitative and quantitative review is presented. A quick functional integrity evaluation is provided by video taping of the heads-up display and the radar scope during the mission. A Radar Diagnostic Instrumentation Pod (RDIP) records the Display Multiplexed Bus, the Digital Bus, and the Programmable Signal Processor Bus to collect the quantitative physical mission data. The RDIP consists of a recorder, a record buffer, and a control panel. The Automated Digital Data Reduction Support System (ADDRESS) is a VAX resident interactive system which performs data retrieval and analysis through FORTRAN and Instrumentation Data Extraction and Analysis Language (IDEAL) programs. R.R.

**A86-32131#**

**RASP - A SYSTEM GENERATING VERY ACCURATE POSITION MARKERS DURING FLIGHT TESTING**

O. B. M. PIETERSEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9802)

This paper describes a system with which the one-dimensional position of an aircraft in the flight direction can be determined with a very high accuracy. The ground- and airborne parts of the system are discussed, as well as the factors which influence the accuracy. It is shown that the attainable accuracy is in the order of 0.3 meter if the aircraft flies at low altitude above the centerline of the runway. If the aircraft taxies, a situation often occuring during take-off and landing trials, the accuracy is better than 0.1 meter. Author

**A86-32142#**

**PERFORMANCE CHARACTERISTICS OF TRANSPONDER-AIDED VERSUS GPS-AIDED INERTIAL NAVIGATION SYSTEMS**

C. O. SMITH, JR. and D. J. BIEZAD (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p. refs
(AIAA PAPER 86-9817)

By combining excellent short term inertial navigation system (INS) performance with the long term performance benefits of the Global Positioning System (GPS) a beneficial synergistic effect can be obtained, and integrated GPS-INS (IGI) covariance analysis packages have been employed to develop high order error models. This paper is concerned with a modification of an IGI simulation program, taking into account the necessity to improve the Completely Integrated Reference and Instrumentation System (IRIS). This improvement is required to test the extremely accurate navigation systems now built by industry. A covariance analysis showed that the CIRIS model aided by GPS performed much better than the CIRIS alone, as expected, but not substantially better than the GPS/INS model with the ground transponders eliminated. For this reason, the potential exists to increase reference trajectory accuracy while simultaneously decreasing problems in routing, logistics, reliability, and maintainability of the transponders. G.R.

**A86-32578**

### PERFORMANCE ANALYSIS OF AIRBORNE PULSE DOPPLER RADAR

P. E. HOLBOURN and A. M. KINGHORN (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 12-16.

Design of a satisfactory radar waveform requires that a number of design trade-offs be considered. It is thus an essential part of the design process to make parametric analyses of detection performance. This paper presents the unique features of a computer program that has been developed to perform such calculations for high and medium PRF systems. Clutter levels are computed in all ambiguous range-doppler cells for a variety of flight geometries and ground clutter models. The effects of receiver eclipsing, sidelobe clutter and mainbeam clutter are included. Target detectability is calculated for all values of range and Doppler within a specified envelope. These results are expressed graphically in the form of a blindzone diagram. The obscuration effects of clutter are expressed as a clutter loss. Blindzone diagrams for notional high and medium PRF systems are presented. The variation in performance of a medium PRF system to radar altitude and transmitter peak power is investigated. Author

**A86-32579**

### EFFICIENT, CLOSED-FORM COMPUTATION OF AIRBORNE PULSE-DOPPLER RADAR CLUTTER

J. K. JAO and W. B. GOGGINS (MIT, Lexington, MA) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 17-22. DARPA-sponsored research. refs

Closed-form expressions are derived for airborne pulse-Doppler radars to calculate the ground clutter of a range-Doppler cell under that flat earth assumption. These expressions enable accurate and efficient computation of both radar sidelobe and main lobe clutter for an arbitrary combination of radar pulse-Doppler waveform and low altitude flight configurations as defined by platform speed and dive angle. The results should be useful in the simulation and evaluation of airborne radar performance. Author

**A86-32581**

### ADVANCES IN SECONDARY SURVEILLANCE RADAR SYSTEMS

R. J. W. SCLATER (Marconi Radar Systems, Ltd., Chelmsford, England) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 29-33.

The features of modern monopulse secondary surveillance radar (SSR) system, called Messenger, are discussed. The structural details of the system, including a new antenna design, the interrogator-responser, the decoder, the plot former, and plot processor, are described. The monopulse SSR, which requires only a single reply to obtain target azimuth, overcomes the disadvantages of the fruiting and the high number of lost replies encountered by the conventional SSR. In addition, a monopulse SSR can operate in a stand-alone configuration and can be upgraded to Mode S. Diagrams and schemes are included. I.S.

**A86-32601**

### A RADAR ANALYSIS PROGRAM FOR EVALUATING AND MONITORING PRIMARY AND SECONDARY RADAR SYSTEMS

T. BERGENSTOFF, P. R. CLAUSEN, and F. THOMSEN (Royal Danish Air Force, Vedbaek, Denmark) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 146-150.

This paper describes a Radar Analysis Program for evaluation and monitoring of a Radar System. The program is a general purpose facility for all Radar System containing a Primary and a Secondary radar. The program only requires data from the extractors of the Primary and Secondary Radar. The program has facilities for evaluating the performance of individual beams in 3 Dimensional Radar Systems and height accuracy of Height Finders using IFF mode C informations. The program evaluates the radar performance by analyzing the association of Primary and Secondary Plots of targets of opportunity. This method drastically reduces expenses to Test Flights and permits a continuous quality monitoring of a Radar System. The program has been used successfully for several years for monitoring and evaluating Danish military and civilian Air Traffic Radar Systems. Author

**A86-32615**

### PARAMETERS OF A DEDICATED WEATHER RADAR FOR TERMINAL AIR NAVIGATION, TRAFFIC CONTROL AND SAFETY

P. R. MAHAPATRA (Indian Institute of Science, Bangalore, India) and D. S. ZRNIC (NOAA, National Severe Storms Laboratory, Norman, OK ) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 235-240. refs

The interservice NEXRAD Doppler weather radar system, which is under development and proving, is expected to significantly aid in fulfilling FAA's projected aviation weather observation needs in the enroute sector. However, there are questions about its adequacy for the highly dense and dynamic operations ocurring in terminal areas. The constraints arise both from its basic design parameters as dictated by its multi-use role and from its location as part of a national grid. There is need for dedicated terminal area weather radars, especially at large and busy airports. For economy and faster implementation, it is desirable to use as much of NEXRAD hardware and software as possible in these terminal area radars, and only modify the operating parameters to suit dedicated terminal area operation. This paper provides the outline for choice of parameters for such a role and indicates a possible set of parameters. Author

**A86-32626*** General Electric Co., Philadelphia, Pa.

### SPACE BASED RADAR APPLICATION TO AIR TRAFFIC CONTROL

W. J. CAIME (General Electric Co., Space Systems Div., Valley Forge, PA) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 312-321. NASA-supported research. refs

Future control of increasing air traffic on international routes will require significant advances in techniques employed. Development is underway, but at this time does not include addition of radar coverage of vast areas of oceanic traffic. This paper addresses the potential for a space-based radar to provide detection and track of aircraft in future traffic scenarios. Factors that must be considered in further tradeoff and concept optimization are discussed. These include: (1) satellite constellation characteristics and associated coverage, (2) efficient use of available energy in track-while-scan strategies, (3) development of tracker approaches to accommodate inherent system constraints, and (4) the application of transponders to assist in dense traffic environments. The analysis assumes the continued development and availability of technology required for high spacecraft power systems (hundreds of kilowatts), and for radar subclutter visibility. Author

**A86-32627**

### SPACE-BASED BISTATIC RADAR - OPPORTUNITY FOR FUTURE TACTICAL AIR SURVEILLANCE

P. K. LEE and T. F. COFFEY (Mitre Corp., Bedford, MA) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 322-329. USAF-supported research. refs

A space-based bistatic radar (SBBR) in geostationary orbit would be useful for future tactical air surveillance. It should be technically feasible to develop such a radar by the mid-1990's, at which time several critical technologies will have reached maturity for the application. This paper presents a conceptual design of an SBBR and a rough estimate of the gross weight of the space segment, based on the projected technologies. Author

**A86-32631**

**RAID COUNT BY AUTOCORRELATION**

K. J. HAMMERLE (Boeing Aerospace Co., Seattle, WA) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 350-354.

It has been hypothesized that a radar can accomplish an aircraft raid count, despite the efforts of an escort jammer, if an autocorrelation operation is performed on the received jammer signal. The concept is based on the assumption that a significant amount of jammer energy is scattered into the 'victim' radar receiver by reflection from the 'quiet' aircraft being escorted and that this energy may be detected by autocorrelating the total signal received at the victim radar receiver. This study presents a theoretical analysis of the concept. Equations, which include all pertinent variables, are derived to define the volume of space surrounding the jammer in which quiet aircraft may be detected. Detection contours are plotted for certain specific cases. Author

**A86-32635**

**THE DESIGN, CONSTRUCTION AND EARLY TRIALS OF A NOVEL AIRBORNE SURVEILLANCE RADAR**

J. G. SCHOENENBERGER and P. D. L. WILLIAMS (Racal-Decca Advanced Development, Ltd., Walton-on-Thames, England) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 372-377. refs

Attention is given to a novel airborne surveillance radar that originated in a conventional pulse radar carried under a variety of test aircraft and which was then upgraded to SLAR equipment incorporating a bandwidth processor for the real time recording of images on an inexpensive audio tape deck. Ocean surface imagery of reasonable quality has been obtained by these means. The system is expected to be useful in searches for patterns of shipping and features such as oil slicks and thermal currents in disturbed water. O.C.

**A86-32640**

**MULTIRADAR TRACKING IN THE NEW ATC SYSTEM AT MAZATLAN (MEXICO) AREA CONTROL CENTER**

B. FURCOLO, S. PARDINI, and R. PELAGATTI (Selenia S.p.A., Rome, Italy) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 403-409.

The multiradar tracking system for the Flight Information Region of Mazatlan integrates ATC radars located in western Mexico. Local tracking data are sent after suitable conversion to a central data processing center, which combines the data to generate a single multiradar track for each target. The distributed intelligence system architecture employed eases the workloads of the central processor. New solutions have been adopted for the track-combination algorithm which take into account the accuracy of the cooperating radars, target behavior, and the time of the local track detection. O.C.

**A86-32823**

**OPERATIONAL ACCEPTABILITY OF 2.4 KBPS SPEECH FOR TACTICAL COMMUNICATIONS**

H. SCHECTER (Support Systems Associates, Inc., Lexington, MA) and J. TIERNEY (MIT, Lexington, MA) IN: MILCOM '85 - Military Communications Conference, Boston, MA, October 20-23, 1985, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 171-175. USAF-sponsored research. refs

This paper describes a series of tests aimed at estimating the operational acceptability of 2.4 kbps LPC speech in high acoustic noise, tactical combat environments. F-15 fighter pilots and E3A (AWACS) controllers, operating in their normal acoustic environments, ran simulated combat missions by communicating via a 2.4 kbps test channel. They then 'graded' the channel by means of a brief questionnaire. Three LPC algorithms (with DRT scores of 71, 75 and 80 percent) were used. The results, although not definitive, suggest that purposeful users will accept lower intelligibility than vocoder designers might expect. The results also indicate a need to examine the effect of listeners' acoustic noise level on intelligibility scores. Author

**A86-32824**

**ASSESSING THE INTELLIGIBILITY AND ACCEPTABILITY OF VOICE COMMUNICATION SYSTEMS**

R. L. PRATT (Royal Signals and Radar Establishment, Malvern, England) IN: MILCOM '85 - Military Communications Conference, Boston, MA, October 20-23, 1985, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 176-180.

Methods of assessing the intelligibility and acceptability of voice communication systems are examined. The procedures for the diagnostic rhyme test (DRT) are described. The speech-to-noise ratio data obtained from the DRT are analyzed; the DRT produces intelligibility scores. The utilization of flight simulator sofware packages to estimate the acceptability of voice communication systems is discussed. A comparison of DRT scores and sofware data evaluates the applicability of the communication system. I.F.

**A86-32925#**

**FAA AIR TRAFFIC CONTROL PROGRAM MANAGEMENT TECHNOLOGY APPLICATIONS**

H. E. GARTRELL, D. A. SABESKY, and P. E. FITZGERALD, JR. IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 19 p.

(Contract DOT-FA01-84-C-00017)

The program management technology software tools and state of art processes used by the FAA's National Airspace System (NAS) are identified. The reasons for NAS, and design drivers which impel its improvement, and the main categories of its 90 projects are reviewed. The Air Traffic Control Element, Ground-to-Air Element, Interfacility Communication Element, and Maintenance and Operations Support Element of the NAS are described, and its Program Management System is discussed. C.D.

**N86-22566#** Joint Publications Research Service, Arlington, Va.

**CHIEF ON UNFAVORABLE YEAR FOR SOVIET AIR TRAFFIC CONTROL**

V. SHELKOVNIKOV *In its* USSR Report: Transportation (JPRS-UTR-86-004) p 1-4 12 Mar. 1986 Transl. into ENGLISH from Vozdushnyy Transport (Moscow, USSR), 12 Dec. 1985 p 2

Avail: NTIS HC A05/MF A01

Careful selection and training of air traffic controllers are discussed. The interaction process between traffic services and ground services and improvement of aircraft traffic flow planning system to raise the quality of air traffic control are emphasized. The necessary continuation of finding ways to raise flight safety in air traffic control is reiterated. Human factors in traffic service are considered. E.A.K.

**N86-23580** Department of the Air Force, Washington, D.C.

**GLIDE SLOPE INDICATOR SYSTEM Patent**

I. S. WYATT and H. L. TASK, inventors (to Air Force) 19 Nov. 1985 6 p Supersedes AD-D010173

(AD-D012077; US-PATENT-4,554,543;

US-PATENT-APPL-SN-473392; US-PATENT-CLASS-340-948)

Avail: US Patent and Trademark Office CSCL 01E

A glide slope indicator system in which light from an incoming aircraft's landing light is shaped by spherical/cylindrical lens combination into a line image which strikes a linear photodiode array. By determining which photodiode in the array the center of the line image strikes, the glide slope angle can be determined. An appropriate signal is communicated to the pilot via a pair of indicator lights mounted on the runway depending upon whether the aircraft is above, below or on the desired glide slope angle. GRA

**N86-23581#** IIT Research Inst., Annapolis, Md.

**THE IMPACT OF A TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM ON THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM AND THE MODE S SYSTEM IN THE LOS ANGELES BASIN Final Report, 15 Jan. 1981 - 15 Jul. 1984**

May 1985 133 p refs Prepared in part for Electromagnetic Compatability Analysis Center, Annapolis, Md.
(Contract F19628-80-C-0042)
(FAA-PM-84-30; ECAC-PR-84-003) Avail: NTIS HC A07/MF A01

An analysis was performed to predict the impact of the Traffic Alert and Collision Avoidance System (TCAS) on the performance of selected air traffic control and surveillance systems in the Los Angeles Basin. The predictions involved the impact of minimum TCAS II (TCAS II M) on both the Air Traffic Control Radar Beacon System (ATCRBS) interrogator at Long Beach, and a hypothetical Mode S sensor at Los Angeles (LAX-4), as well as the impact of the combined TCAS I and TCAS II M signal environment on the Long Beach ATCRBS interrogator. These predictions were made using a hypothetical peak Los Angeles Basin airborne deployment and subsets of that deployment. Author

**N86-23582#** Lear Siegler, Inc., Grand Rapids, Mich.

**PRELIMINARY HAZARD ANALYSIS FOR SELF-CONTAINED NAVIGATION SYSTEM**

J. T. REEVES 4 Oct. 1985 18 p
(Contract F09603-85-C-1224)
(AD-A161883; MISC-2037) Avail: NTIS HC A02/MF A01 CSCL 17G

This document constitutes the Preliminary Hazard Analysis (PHA) for the C-130 Self-Contained Navigation System (SCNS) installation. It provides an initial risk assessment of the SCNS installation. The purpose of the PHA is to identify safety critical areas, evaluate hazards, and identify the safety design criteria to be used. The items covered in this analysis are to be used during the design phase and trade-off study period to prevent unsafe concepts, designs, or oversights that could lead to incorporation of hazards in the hardware, the system operation, handling, and maintenance. The scope of this analysis for Data Item 0103 is limited to the SCNS installation task A-kit components (viz wiring harness, brackets, racks, control panels, relay boxes, circuit breakers), B-kit components (e.g., ICDUs, BICU, DVS, INU), and the physical interfaces with existing equipment (e.g., CADC or Sensors, Radar, Air Data Sensors). These items will be analyzed in respect to safe installation, safe hardware, and safe usuage (e.g., installation, removal, in-place test, and handling). GRA

**N86-23583#** Air Force Armament Lab., Eglin AFB, Fla.

**PROCEEDINGS OF THE 12TH BIENNIAL GUIDANCE TEST SYMPOSIUM HELD AT HOLLOMAN AFB, NEW MEXICO ON 22-24 OCTOBER 1985, VOLUME 1**

K. S. MORGAN, P. ROMANOWSKI, L. VALLOT, G. STEIN, and D. ENNS 15 Oct. 1985 252 p Symposium held at Holloman AFB, N. Mex., 22-24 Oct. 1985
(AD-A161996; AD-TR-85-54-VOL-1) Avail: NTIS HC A12/MF A01 CSCL 17G

These proceedings contain papers which were presented at the Twelfth Biennial Guidance Test Symposium. This symposium, hosted by the Central Inertial Guidance Test Facility, Holloman Air Force Base, New Mexico on 22 to 24 Oct. 1985, was directed toward the exchange of information, stimulation of new ideas, and discussion of current techniques associated with the development and evaluation of inertial guidance and navigation systems. The papers presented included such topics as new test and calibration techniques for accelerometers and ring laser gyros, advances in flight reference systems, new test equipment, and new software developments. Papers presented in the classified portion of the symposium are published as Volume 2. Critical technology papers are published as Volume 3. Author (GRA)

**N86-23584#** Department of the Navy, Washington, D. C.

**AN APPARATUS FOR AND A METHOD OF DETERMINING COMPASS HEADINGS Patent Application**

D. G. JABLONSKI, inventor (to Navy) 24 Jun. 1985 12 p
(AD-D012051; US-PATENT-APPL-SN-748248) Avail: NTIS HC A02/MF A01 CSCL 17C

A compass system and method incorporating a global positioning system (GPS), such as the NAVSTAR/GPS multisatellite system, is configured to [illegible] accurate compass heading information without [illegible] by magnetic anomalies and without being [illegible] on the elapsed time since a previous position fix. The compass system comprises, inter alia, two antenna/preamplifiers located, for example, fore and aft a ship or aircraft separated by a predetermined distance d. A microprocessor/minicomputer portion of the system causes an electronic coaxial switch to switch a GPS receiver between the two antenna/preamplifiers automatically thereby measuring their absolute positions. The microprocessor/minicomputer computes and displays on a display unit a compass heading based on the knowledge of the absolute positions of the antenna/preamplifiers and the distance d there between. GRA

# 05

# AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-30090**

**THE APPLICATION OF FRACTURE MECHANICS METHODOLOGY TO THE DAMAGE TOLERANCE ANALYSIS OF THE BOEING 757 AIRPLANE**

S. RAO VARANASI (Boeing Commercial Airplane Co., Seattle, WA) IN: Advances in fracture research (Fracture 84). Volume 5 . Oxford and New York, Pergamon Press, 1986, p. 3469-3484. refs

The functions of fracture mechanics in the residual strength and damage growth elements of the damage tolerance analysis of aircraft structures are analyzed. The characterization of fracture resistance of a material with linear elastic fracture mechanics is examined. The use of the fracture mechanics method to evaluate crack growth by the stress intensity factor is described. The development of a structural inspection maintenance program to determine the type and frequency of inspections required to detect fatigue damage is studied. An example of the damage tolerance analysis of the 757 wingbox lower surface, displaying the applicability of the technique, is presented. I.F.

**A86-30498**

**UNDERSTANDING AND PREDICTING HELICOPTER BEHAVIOR - THEN AND NOW (LECTURE)**

A. GESSOW (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, Jan. 1986, p. 3-28. refs

Theories and techniques used to understand and predict helicopter characteristics are reviewed. The Glauert and Lock momentum-blade element approach, the vortex theory, free-wake method, laser Doppler techniques, and laser holographs employed to explain rotor inflow and wake are described. The application of the inflow/wake theories to the prediction of hover performance is examined. Various ground and flight techniques for evaluating forward flight performance and blade load measurements are discussed. The analyses of aeroelasticity, stability and control, and noise are studied. I.F.

**A86-30550**

### LOGISTICS SUPPORTABILITY CONSIDERATIONS DURING CONCEPTUAL AND PRELIMINARY DESIGN

D. P. SCHRAGE and S. A. MEYER (Georgia Institute of Technology, Atlanta) Vertiflite (ISSN 0042-4455), vol. 32, Mar.-Apr. 1986, p. 48-51.

The concept formulation efforts of the 'light helicopter experimental' (LHX) program, which is based on improving combat effectiveness while reducing life cycle costs (LCCs), are described. The need to study logistic supportability considerations in the synthesis process of aircraft systems is examined. LCCs and logistic costs can be lowered by reducing: (1) the manpower required for support, (2) the cost of spares, (3) the reliance on test equipment, and (4) the cost of post development software support. Six systems for the LHX program aircraft that will lower LCCs are proposed. The economic and noneconomic benefits of the standarization of aircraft designs and the use of common components are studied. The development of a two-level maintenance system and the reduction of manpower are analyzed. The improvement of the reliability and maintainability of mission components and speed to insure self-deployability and sustainability of the aircraft is discussed. The elimination of automatic test equipment is examined. I.F.

**A86-31039**

### THE 7J7 - BOEING'S ANSWER TO THE AIRBUS A320

M. GRANGIER Interavia (ISSN 0020-5168), vol. 41, Feb. 1986, p. 151-153.

An evaluation is made of the design features, performance, and comparative economies of the '7J7' airliner that will compete with the A320 in the 150-seat aircraft market of the 1990s. The propulsion system currently envisioned for the 7J7 uses two counterrotating unducted fans in pusher configuration. Extensive use is to be made of aluminum-lithium alloys and thermoplastic matrix composites, with a view not only to the reduction of airframe weight but of manufacturing costs. The J7J is of approximately the same dimensions as the 727-200, although cabin cross section and wingspan will both be greater. O.C.

**A86-31221**

### COMING UP - THE 330 AND 340

A. PARTIOT Revue Aerospatiale (ISSN 0065-3780), March 1986, p. 12, 13, 15. In English and French.

The designs of the A330 and A340 are described. The A330 is a two-engined aircraft that has a 9300 km range and seats 310 passengers. A range of 12,000 km is provided by the four-engined A340. The operating cost savings possible with these aircraft due to weight reductions and new technologies are discussed. I.F.

**A86-31331#**

### X-29 REVIVES THE EXPERIMENTAL AIRCRAFT

J. N. ALLBURN, J. P. RETELLE, JR. (DARPA, Arlington, VA), N. J. KRONE (University Research Foundation, College Park, MD), and W. E. LAMAR Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 30-33.

The canard-equipped X-29 aircraft, although built to fighter specifications, is actually a demonstrator project for innovative aerodynamic, structural and flight control concepts. The aircraft has shown that aeroelastic tailoring of advanced composites eliminates divergence of a forward swept wing, resulting in high aerodynamic and structural efficiency at high lift, increased maneuverability, agility and potential STOL. The X-29 offers control at low speed and high angle of attack, and in production aircraft would mean reduced weight and systems cost, and increased range and payload. Basic research was required before flying while accommodating maneuvering variable camber with aft flaperons, full authority canards, high pitch instability and the use of digital flight controls to stabilize an inherently unstable aircraft. The thin wing section and the control laws for stabilizing the negative static margin were major design problems that have seemed solved within the flight test envelopes thus far explored. The program has demonstrated the strength of pre-flight engineering and simulation work, while underscoring the need for flight testing to explore flight regions that cannot be well-defined without hard data to verify and improve existing models. M.S.K.

**A86-31332#**

### UNUSUAL AERODYNAMICS OF X-29

G. SPACHT, J. CALANDRA, M. MOORE, T. TAGLARINE, J. CHIN (Grumman Corp., Aircraft Systems Div., Bethpage, NY) et al. Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 34-36, 38.

The X-29 is controlled by the pilot through the medium of a triple channel flight control system (FCS) which compensates for the 35 percent negative margin of stability of the aircraft. The aeroelasticity tailored forward-swept supercritical profile composite wings furnish lower wing profile drag during transonic maneuvering, compared to an aft-swept wings. Less drag is also present at low speeds and high angles of attack (AOA). Forward wing sweep confines separation to inboard regions to maintain attached flow at the wing tips, even at high AOA, when the full-span ailerons remain effective. Nose vortex shedding is symmetrical because of strakes which eliminate sideslip. Flow interaction between the canards and wings provides more lift for the canards at high AOA and canard downwash retards flow separation on the wings. The aerodynamic coefficients are maximized by variable camber and relaxed static stability. Three-surface trim is controlled by the multimode FCS, which can function reliably in various degraded modes, thus fulfilling a design goal of risk reduction. M.S.K.

**A86-31333*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

### X-29 FLIGHT - ACID TEST FOR DESIGN PREDICTIONS

T. W. PUTNAM, K. L. PETERSEN, S. D. ISHMAEL, and W. J. SEFIC (NASA, Flight Research Center, Edwards, CA) Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 40-42.

The X-29 flight test data are being disseminated to interested industrial and military users as fast as it becomes available. The aircraft is extensively instrumented with accelerometers and pressure sensors and optical sensors for measuring wing deflection. The thoroughness of preflight preparations permitted a rapid advance through initial test checkpoints, which have both confirmed many predictions and revealed several discrepancies. The flight envelope had been expanded to Mach 1.1 and an altitude of 40,000 ft by December 1985. Notably, the X-29 has provided in-flight data which could not be faithfully depicted in a simulator, e.g., flare procedures during landing, and has shown that the stability adjustments, although adequate for controlling the aircraft, are not rapid enough to offer a satisfactory margin of harmony. The tests are now being performed in the transonic regime, where supercritical airfoil and forward swept wing drag reduction become significant factors. M.S.K.

**A86-31334#**

### X-29 AIMS AT APPLICATIONS

T. M. WEEKS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and T. J. WIERZBANOWSKI (USAF, Flight Test Center, Edwards AFB, CA) Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 44-46.

Once beyond high angle of attack (AOA) and transonic regime flight testing, the two X-29 research aircraft will be used to increase technology transition, expand the flight envelope of modern aircraft, for military development and testing and to incorporate and test improved or new technologies. A Committee has been established to facilitate the transfer of data from the program to government and industrial users. The ground and flight tests have furnished data on wing/canard flow interactions, structural aeroelastic effects, flutter and aeroservoelastic modes and excitation, analysis and testing techniques, flying qualities for superaugmented aircraft, and the effects of static instability. A jump strut may be tested on one of the aircraft in an attempt to shorten the necessary runway length. Also, a jet fuel-powered emergency power unit is being studied as an emergency power unit. Finally, the flight control system programming may be rewritten in ADA. M.S.K.

**A86-31336#**
**SOVIET AIRCRAFT CLOSE TECHNOLOGY GAP**
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 56-59.

Soviet fighter design is generally ruled by the principle of evolutionary advances in proven practices and technologies. Aircraft designs are generated by indigenous talent and by concepts copied from the West. A centralized design bureau guides the efforts of separate design institutions, each normally devoted to producing a particular type of design. Cross-fertilization occurs between the different houses, e.g., delta wings onboth the MiG-21 and the Sukhoi Su-9. The aircraft are produced on a wartime basis, i.e., quantity, so ground maintenance crews are smaller to exploit the surplus of aircraft, which offsets a lack of quality or hardware sophistication. The turn-of-the-century MiG-2000 is projected to have a 500 n. mi. combat radius, a Mach 2.6 dash, GTO weight of 20 tons, and thrust/weight ratio of 1.35. Fuel consumption concerns will force the introduction of a large proportion of composite materials for structural parts. A digital avionics cockpit would have an inclined seat to permit 9 g maneuvers. The fighter would incorporate stealth technology and would carry sufficient armament for a kill on the first pass, in keeping with the historic requirements of Soviet aircraft for a high instantaneous turn rate but a deficiency in sustained turning.
M.S.K.

**A86-31341#**
**SWEDEN'S GRIPEN - A TOUGH BIRD TO TANGLE WITH**
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, March 1986, p. 52-55.

The JAS-39 Gripen design has been selected by the Swedish government as the nation's multirole fighter into the 21st century. It will have an airframe amenable for diverse missions, a modified version of the F404J engine, and maneuvering canards. One model of the aircraft will serve ground attack, two-seat trainer, fighter/interceptor and sea-surveillance roles, with adjustments between missions handled by reprogrammable digital avionics and a distributed on-board set of microprocessor-computers. The wing span will be 26 ft, length 46 ft, and GTOW of 18,000 lb without weapons, 22,400 lb with stores. The airframe will be 30 percent carbon composites, i.e., the wing, the vertical tail, canards, intake ducts and the landing gear doors. The thrust/weight ratio of takeoff will be 1. The JAS-39 is to have STOL capabilities from 500 m of rural roads widened to 550 ft. Thrust reversal will be obviated by using the canards to lift the nose for aerodynamic braking. Ease-of-repair features are to be built into the aircraft to facilitate reliability and maintainability when the aircraft is serviced by conscripts with a short service record. The Gripen will be statically unstable and flown by means of the computers, which will furnish the pilot with three CRT screens of data plus HUD. A 28 deg inclined seat will aid the pilot in sustained high-g turns. M.S.K.

**A86-31344**
**SU-27 - SUKHOI PLAYS ITS FLANKER**
B. SWEETMAN Interavia (ISSN 0020-5168), vol. 41, March 1986, p. 275-278.

A discussion is presented concerning the design features and probable performance characteristics of the USSR's Su-27 twin-engine fighter, which is comparable to the U.S.'s F-14 and F-15 and incorporates numerous configurational features of Western fighter aircraft. Among such details are a high visibility bubble canopy, strake/wing planform, blended wing/fuselage cross section, and an I/J-band coherent Doppler radar that may be based on F/A-18 APG-65 radar design data obtained through espionage. IR search-and-track and telescopic video sensors are also incorporated underneath the engine air intakes. The most perplexing aspect of the Su-27's design is the mission which it is required to accomplish; it is presently conjectured to be a long range 'intruder' aircraft. O.C.

**A86-31345**
**AEROSPATIALE AS.350 B1 - THE MOUNTAIN SQUIRREL**
M. LAMBERT Interavia (ISSN 0020-5168), vol. 41, March 1986, p. 289-292.

A design feature and performance evaluation is presented for the recently certificated B1 version of the AS.350 high altitude/hot atmospheric conditions helicopter for mountain terrain operations. Comparisons are made between the B1 and its mountain-optimized predecessor from the same manufacturer, the Lama; the B1 is noted to possess a more fuel-efficient engine and fly faster, therefore being able to accomplish more in a given period of time than a Lama despite its 100-kg smaller payload. Dimensions and operating parameters are presented. O.C.

**A86-31346**
**NEW INTERFACES IN THE COCKPIT**
M. LAMBERT Interavia (ISSN 0020-5168), vol. 41, March 1986, p. 295-297.

General aviation, military aircraft, helicopter and airliner flight decks are being transformed by three dynamically developing technologies: digital avionics, side stick controllers, and pilot voice control procedures. Attention is given to the 'Starship' executive tubes possessing their own symbol generators. Side stick controllers are considered ideal pilot interfaces with a fly-by-wire system such as that of the A320 airliner, clearing the pilot's line-of-sight to the windscreen and flight deck. Special usefulness is noted in the application of voice control technology to helicopters engaged in nap-of-the-earth operations. O.C.

**A86-31413**
**A STUDY OF THE EFFECT OF CERTAIN FACTORS ON THE FATIGUE STRENGTH OF STRUCTURAL IRREGULARITIES IN THE AIRFRAME OF AIRCRAFT [ISSLEDOVANIE VLIIANIIA NEKOTORYKH FAKTOROV NA DOLGOVECHNOST' KONSTRUKTIVNYKH NEREGULIARNOSTEI PLANERA SAMOLETA]**
N. V. KOSHELEV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 51, 1984, p. 35-39. In Russian. refs

Problems associated with ensuring the fatigue strength of the airframe of an aircraft in irregular zones at the stage of design are examined. In particular, attention is given to factors determining the fatigue strength of typical joints, such as those securing the tip of a stiffness element to the skin and butt joints between skin panels, in relation to the design parameters. Practical recommendations concerning the selection of the joint size are given. V.L.

**A86-31657#**
**PERIODIC CONTROL FOR MINIMUM-FUEL AIRCRAFT TRAJECTORIES**
W. GRIMM, K. H. WELL (DFVLR, Institut fuer Dynamik der Flugsysteme, Wessling, West Germany), and H. J. OBERLE (Hamburg, Universitaet, West Germany) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 169-174. refs

The problem of minimizing fuel consumption of an aircraft is formulated as an optimal control problem with periodic boundary conditions. Two problems are considered: one with constant aircraft weight and one with variable weight. Numerical solutions are computed via a multiple-shooting method and consist of bang-bang control actions for power setting. In comparison to the steady-state solutions, savings in fuel consumption for an F-4-type aircraft are approximately 2 percent. The solution obtained is shown to satisfy the second-order sufficiency conditions for a weak local optimum.
Author

**A86-31849**
**COCKPITS FOR 2010 AND BEYOND**
P. I. SUMMERS (McDonnell Aircraft Co., St. Louis, MO) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, Feb. 1986, p. 17-20.

A proposed cockpit design for fighter aircraft is described. The ground-based mission planning system is discussed. The use of a forebody concept to accommodate the physiological needs of the crew is examined. An armrest control module is proposed for controlling attitude and thrust. The encapsulation of the crew station and display systems such as the helmet mounted sight and display system are studied. The application of artificial intelligence and biocybernetics to the cockpit of the aircraft is analyzed. I.F.

**A86-32067**

**COMPARISON OF F-101 EJECTION SEAT AND ACES II STATIC AERODYNAMIC COEFFICIENTS**

L. J. SPECKER (USAF, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) SAFE Journal, vol. 16, Spring 1986, p. 6-13. refs

High-speed ejection trajectories and accelerations remain unpredictable and low-speed ejections can be predicted only if the simulation program has been updated to reflect changes in ejection seat design and aerodynamic influencing factors. This paper describes the computer simulation model, the aerodynamic adjustments necessary to achieve correlation with test data, and the results obtained after a comparison was made between F-101 ejection seat and Advanced Concept Ejection Seat (ACES) II test data. It was found that the static aerodynamic coefficients of the F-101 were not similar to those of the ACES II when the seat reference point is used as the moment reference center. Moreover, each of the six static aerodynamic coefficients of the F-101 are significantly different from those of ACES II when measured in low-speed wind tunnel tests. It is concluded that static aerodynamic coefficients collected using the F-101 ejection seat cannot be used to calculate the performance of an ACES II when aerodynamic forces are predominant in the ejection sequence. K.K.

**A86-32074#**

**NEW RESEARCH AIRCRAFT FOR DFVLR**

Dornier-Post (English Edition) (ISSN 0012-5563), no. 3, 1985, p. 15-17.

Features relating to the structure and performance of the Dornier 228 aircraft are described and a summary of future flight projects is given. The rectangular cabin (6.30 m long, 1.35 m wide, 1.55 m high) permits the simultaneous housing of different control, evaluation and recording devices as well as scientific pesonnel. Complex sensors which may be installed include MSS, SAR, SLAR, and SCAT. When flying at 1000 ft, the aircraft's noise level of 74.1 dB(A) is 5.9 dB(A) below the admissible limit, allowing for research missions over residential areas. Dornier 228 offers excellent low-speed flying characteristics around 100 km/hr as well as a high cruise speed with a maximum of 430 km/hr; and the use of a mobile oxygen system allows flight measurements up to an altitude of 25,000 ft. Because of this performance spectrum, the Dornier 228 is capable of such projects as the thermal mapping of temperature distribution in city regions and the monitoring of the ocean, forests, and the atmosphere. K.K.

**A86-32075#**

**THE IA 63 TRAINER**

B. STRAETER and K. H. MOHR Dornier-Post (English Edition) (ISSN 0012-5563), no. 3, 1985, p. 29-31.

After three years of preparatory work, a first agreement on cooperation was signed in 1979 by the Argentine Air Force and Dornier GmbH for the development of the IA 63 basic/advanced jet trainer. The IA 63 is a single-engined jet trainer with a shoulder-mounted nonswept trapezoidal wing with a supercritical section. This wing, characteristic of the IA 63, was designed for a high maximum lift during takeoff and landing and fo low drag and high lift during cruise and in maneuvers. The tricycle landing gear with single wheels is suitable for landings on unpaved airstrips, and the seat position coupled with a one-piece cockpit canopy opening to the rear offers excellent visibility. The success of IA 63 prototypes in October 1984 and in August 1985 attests to its reliability in training missions, simplicity is maintenance, and inherent level of technological expertise. K.K.

**A86-32076*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**X-29A ADVANCED TECHNOLOGY DEMONSTRATOR PROGRAM OVERVIEW**

W. J. SEFIC (NASA, Flight Research Center, Edwards, CA) and W. CUTLER (Grumman Corp., Grumman Aircraft Systems Div., Bethpage, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 16 p.
(AIAA PAPER 86-9727)

The present discussion of the X-29A forward-swept wing experimental aircraft's functional flight program and concept evaluation program gives attention to the program management structure for a test team that encompasses NASA, the U.S. Air Force, and the prime contractor for the X-29A. The preflight, flight-functional, envelope-expansion and flight research test objectives of the program are also noted, together with the qualitative characterizations obtained to date for both a limited envelope flight control system and one for an expanded envelope. O.C.

**A86-32077*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FLIGHT TEST OF A DECOUPLER PYLON FOR WING/STORE FLUTTER SUPPRESSION**

F. W. CAZIER, JR. (NASA, Langley Rearch Center, Hampton, VA) and M. W. KEHOE (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 13 p. refs
(AIAA PAPER 86-9730)

The decoupler pylon is a NASA concept of passive wing-store flutter suppression achieved by providing a low store-pylon pitch frequency. Flight tests where performed on an F-16 airplane carrying on each wing an AIM-9J wingtip missile, a GBU-8 bomb near midspan, and an external fuel tank. Baseline flights with the GBU-8 mounted on a standard pylon established that this configuration is characterized by an antisymmetric limited amplitude flutter oscillation within the operational envelope. The airplane was then flown with the GBU-8 mounted on the decoupler pylon. The decoupler pylon successfully suppressed wing-store flutter thoughout the flight envelope. A 37-percent increase in flutter velocity over the standard pylon was demonstrated. Maneuvers with load factors to 4g were performed. Although the static store displacements during maneuvers were not sufficiently large to be of concern, a store pitch alignment system was tested and performed successfully. One GBU-8 was ejected demonstrating that weapon separation from the decoupler pylon is normal. Experience with the present decoupler pylon design indicated that friction in the pivoting mechanism could affect its proper functioning as a flutter suppressor. Author

**A86-32082#**

**MODELING OF AIRCRAFT CRUISE PERFORMANCE USING ACCELERATION AND DECELERATION MANEUVERS - RESULTS AND APPLICATION**

T. R. YECHOUT (U.S. Air Force Academy, Colorado Springs, CO) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p.
(AIAA PAPER 86-9735)

A flight test technique has been developed under NASA Dryden sponsorship to predict aircraft cruise performance characteristics. The technique used acceleration and deceleration maneuvers to define baseline aerodynamic and propulsion system characteristics which were then input to a performance modeling prediction program. Conventional stabilized 'speed power' tests, which are normally used for cruise performance definition, can comprise a large portion of the flight time in a program. A significant reduction in flight time was estimated using the performance modeling approach, with associated savings in cost and schedule. A 20-hour verification flight test program was accomplished using a Learjet Model 35 aircraft. Author

**A86-32083#**

**X-29A FLIGHT FLUTTER DATA ANALYSIS BY ADVANCED METHODS**

M. L. RUSSO (Grumman Corp., Data Systems Div., Holtsville), M. P. HEALY, and M. P. BROCK (Grumman Corp., Aircraft Systems Div., Calverton, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p. refs
(AIAA PAPER 86-9737)

Because of the X-29 forward-swept wing experimental aircraft's novel structural dynamics, flight flutter testing is initially conducted without a shaker system; it is therefore necessary to estimate aircraft flutter parameters on the exclusive basis of random excited data. The approach presented uses a maximum likelihood parameter identification technique. A computer code, 'TASKX', employs an initial model together with flight data to make maximum likelihood estimates of the true aeroelastic model from which flutter parameters are extracted. Favorable results are obtained using TASKX to analyze fin, wing, and fuselage response measurements from the X-29. O.C.

**A86-32096#**

**FLIGHT TEST TECHNIQUES USED FOR CARRIAGE LOAD MEASUREMENTS AT LARGE UNDERFUSELAGE STORE CONFIGURATIONS ON TORNADO COMBAT A/C**

F. J. RUDOLPH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p.
(AIAA PAPER 86-9755)

Flight tests have been carried out in order to measure the carriage loads associated with the Multi-Weapon Carriage System (MWCS) of the Tornado combat aircraft. In particular, carriage loads have been collected from large underfuselage stores in a container configuration (MW1), a quadruple store carriage system (QSC), and an aerial target system (DATS). Detailed descriptions of the loads instrumentation, calibrations, software preparations and tests techniques, are given, and the load measurement data are presented in graphic form. A line drawing illustrating the trajectory of the container system at the moment of jettison is provided. I.H.

**A86-32097*#** PRC Kentron, Inc., Hampton, Va.

**NATURAL LAMINAR FLOW FLIGHT EXPERIMENTS ON A TURBINE ENGINE NACELLE FAIRING**

C. J. OBARA (PRC Kentron, Inc., Hampton, VA), E. C. HASTINGS, J. A. SCHOENSTER, T. L. PARROTT, and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p. refs
(AIAA PAPER 86-9756)

Flight experiments are being conducted with the objective to investigate the interactions between acoustic disturbances and laminar flow in the flight environment. In the experiments, the laminar boundary layer on the nacelles will be exposed to discrete and broadband external noises, and the effect of varying noise levels and frequencies on the stability of the laminar flow will be studied. The present paper provides an overview of the complete project and a status report on the results which have been obtained. The flight experiment is conducted with the aid of a modified research aircraft. The phase I flight tests are concerned with a quick and simple determination of natural laminar flow (NLF) behavior on an engine nacelle. Attention is given to instrumentation, the acoustic noise source, flow visualization, and the test results. G.R.

**A86-32098#**

**SINGLE HEADING CLIMBS - AN ALTERNATE TECHNIQUE FOR DETERMINING PERFORMANCE**

A. J. DEPASQUALE and I. J. BAILLIE (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9757)

This paper presents an alternate flight technique for determining actual climb performance levels on jet transport category airplanes. The current technique requires demonstration of reciprocal heading crosswind climbs. The new technique requires only single heading climbs using an INS installation and adhering strictly to onboard stability monitoring criteria. This concept has been validated by reanalysis of previous test results from reciprocal heading crosswind climb demonstrations, and by use of stringent onboard stability monitoring criteria during the MD-83 program. FAA Draft Advisory Circular AC No. 25-XX accepts this concept as valid. It will reduce the current flight hours required to demonstrate actual climb performance levels by 50 percent, shorten test schedule time, and reduce the total man-hours spent in data analysis. Author

**A86-32101#**

**DEVELOPMENT AND FLIGHT TESTING OF THE T-2 CONTROL CONFIGURED VEHICLE**

M. YASUE, A. TAKEKOSHI, H. KANNO, M. NAKAO, K. SHIBATA (Japan Defense Agency, Technical Research and Development Institute, Tokyo) et al. AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p.
(AIAA PAPER 86-9763)

The design, development, and testing of the T-2 control configured vehicle (CCV) are described. Th installation of a triplex digital fly-by-wire (FBW) flight control system into the T-2 is analyzed. The components of the FBW control system and the modes of the CCV are examined. The flight testing of the T-2 CCV is studied; the four phases of the testing include: (1) system checkout/envelope expansion/preliminary evaluation, (2) handling qualities evaluation, (3) CCV mode evaluation, and (4) operational evaluation. The test data reveal that the flight control system reliability and handling qualities are satisfactory. The application of the CCV concept and FBW system to modern high performance aircraft is discussed. I.F.

**A86-32102#**

**INTEGRATING THE PILOT INTO THE COCKPIT**

M. B. JOHNSTON and A. V. WOLFE (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9765)

The designing of cockpits to fulfill mission requirements is studied. The need for pilot-vehicle interface (PVI) is discussed. The objectives of the PVI Project Lead are examined. The use of simulation in cockpit design is described. Examples displaying the progression of cockpit design complexity and workloads are presented. I.F.

**A86-32103#**

**T-46A FLIGHT TEST RESULTS**

W. H. SHAWLER (Fairchild Republic Co., Edwards, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9766)

The handling qualities, one G and accelerated stalls, takeoff and landing characteristics, engine operation, and subsystems of the T-46 aircraft are analyzed. The configuration and capabilities of the T-46 aircraft are described; engine and flight control system designs are exmined. The test data reveal that improvements in the lateral and longitudinal trims, stall warning, and speed brake panels are required. The T-46 performance was compared to the 62 percent model aircraft, which is a composite aircraft weighing

842 pounds; good correlation of performance data is observed. I.F.

**A86-32107*#** San Jose State Univ., Calif.
**FLIGHT TEST PLANNING AND PARAMETER EXTRACTION FOR ROTORCRAFT SYSTEM IDENTIFICATION**
J. C. WANG, M. Y. DEMIROZ (San Jose State University, CA), and P. D. TALBOT (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 16 p. refs
(Contract NCC2-297)
(AIAA PAPER 86-9772)

The present study is concerned with the mathematical modelling of aircraft dynamics on the basis of an investigation conducted with the aid of the Rotor System Research Aircraft (RSRA). The particular characteristics of RSRA make it possible to investigate aircraft properties which cannot be readily studied elsewhere, for example in the wind tunnel. The considered experiment had mainly the objective to develop an improved understanding of the physics of rotor flapping dynamics and rotor loads in maneuvers. The employed approach is based on a utilization of parameter identification methodology (PID) with application to helicopters. A better understanding of the contribution of the main rotor to the overall aircraft forces and moments is also to be obtained. Attention is given to the mathematical model of a rotorcraft system, an integrated identification method, flight data processing, and the identification of RSRA mathematical models. G.R.

**A86-32108#**
**FLIGHT TEST SIMULATION OF THE T-46**
J. C. PICK (USAF, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9773)

This paper describes the development and structure of the T-46A flight test simulation at the U.S. Air Force Flight Test Center, and emphasizes two interesting aspects of the simulation: (1) an electrohydraulic force-feel system is driven by a digital computer to model a reversible flight control system; and (2) data for extremely high angles-of-attack are incorporated into the simulation in order to simulate aircraft stall, departure, spin, and recovery. The use of this simulation as a tool to make performance and flying qualities testing safer, more effective, and more efficient is also discussed. Author

**A86-32109#**
**F-14A LOW ALTITUDE HIGH ANGLE OF ATTACK SIMULATION AND FLIGHT TEST PROGRAM**
R. J. GOODMAN and P. E. CONIGLIARO (Grumman Corp., Aircraft Systems Div., Calverton, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p.
(AIAA PAPER 86-9774)

The loss of several F-14A aircraft in apparent spin-related accidents during 1976-79 has led to the initiation of a series of flight test programs to investigate the high angle of attack departure characteristics of this twin engine, variable-sweep fighter. A review is presented regarding the technical considerations in applying ground-based piloted simulation to support F-14A high angle of attack flight testing in general, and the Low Altitude Asymmetric Thrust Test Program, in particular. It is found that piloted simulation support is a necessary means of enhancing flight test safety, productivity, and data analysis. Attention is given to simulation model updates, simulation fidelity issues, simulation-flight test philosophy, simulation test planning and on-site support, simulation verification flight testing, and critical store configuration testing. G.R.

**A86-32112#**
**HOW TO MAKE SIMULATORS FLY LIKE AIRPLANES**
L. G. JANSSENS and T. MARSHALL (USAF, Wright-Patterson AFB, OH) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p.
(AIAA PAPER 86-9777)

A new technique for generating simulation data packages from flight testing data is described. The use of a digital flight test data system, an intgrated math model, and a six-degree-of-freedom engineering simulation model is examined. The performance, propulsion, handling qualities, and stability and control characteristics of the test aircraft were measured, and the data was evaluated with the simulation data system. The procedure for measuring angle of attack and sideslip is discussed. Good correlation between flight test data and computer model simulation data is observed. I.F.

**A86-32113#**
**INVESTIGATION OF MAIN LANDING GEAR TIRE TEMPERATURES DURING TAXY-OUT AT HEAVY TAKE-OFF MASSES**
H. KERNER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9778)

Main gear tire temperature behavior in the Tornado aircraft is evaluated. The procedures for measuring the tire bead temperature of 30 x 11.50 and 30 x 14.5 tires with 24 and 26 ply ratings are described. The effects of ambient temperature, taxi-speed, and brake activity are studied. The testing of the tires at 6 and 33 C reveals that the tire bead temperature is dependent on radiation and a linear relationship between tire temperature and ambient temperature is observed. Brake activity and taxi-speed data are compared to towing data; a higher tire bead temperature caused by taxi-speed is detected in the taxiing aircraft. The cooling behavior of the tires is analyzed. The data reveal that the 24 ply rating tire is applicable for aircraft with low masses and shorter turn-around times, and the 26 ply rating tire displays good performance due to improved stiffness and higher mass. I.F.

**A86-32115#**
**X-29 GROUND AND FLIGHT SUBSYSTEM TESTING**
E. TOBIASON and R. MCSHEA (Grumman Corp., Edwards, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9781)

The concept of a manned research aircraft dedicated to the single purpose of testing high-risk aerospace technology was revitalized with the X-29 Advanced Technology Demonstrator. The first flight with the X-29 was conducted on December 14, 1984. The flight test environment is considered along with the X-29 subsystem design, a subsystem description, test plans aspects of program development, Calverton ground test results, and initial flight testing. It is pointed out that as a result of the 32 flights flown to date, many of the original flight test objectives have been attained. Thus, the advanced technologies incorporated in the X-29 design have proven feasible in actual flight. G.R.

**A86-32116#**
**INFLIGHT EXCITATION OF THE F-16XL**
S. C. TIERNEY (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 6 p.
(AIAA PAPER 86-9782)

During flight testing of the General Dynamics F-16XL fighter aircraft, a 2.5 Hertz oscillation in the aircraft longitudinal axis was encountered in the 0.90-0.95 Mach range at all altitudes. This oscillation was not predicted on the contractor simulator, which utilized flight test derived aerodynamics and a model of the flight control computer. Flight testing identified the amplitude of the oscillation to be system gain-dependent in the longitudinal axis.

The inflight excitation test procedure was developed to obtain the aircraft frequency response inflight, utilizing the actual hardware and aerodynamics at any condition within the flight envelope. Inflight excitation test results indicated a high gain system in the longitudinal axis, with -180 degrees of phase angle in the frequency range where the longitudinal oscillation existed. A gain nonlinearity in the aircraft actuators was identified as a major contributor to the limit cycle oscillation. The test procedure discussed has potential application to future aircraft with augmented flight controls by reducing flying qualities test time and increasing the level of safety involved in opening an aircraft flight envelope. Author

**A86-32118*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IN-FLIGHT FLOW VISUALIZATION OF F-106B LEADING-EDGE VORTEX USING THE VAPOR-SCREEN TECHNIQUE**

J. E. LAMAR, R. A. BRUCE, J. D. PRIDE, JR., R. H. SMITH, P. W. BROWN (NASA, Langley Research Center, Hampton, VA) et al. AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p. refs

(AIAA PAPER 86-9785)

A flight program was conducted with the objective to study the vortex flow systems existing around the F-106B aircraft. Level 1-G decelerating flight with varying angle of attack was considered along with conditions involving G levels in the range from 4.5 to 5.5 and angles of attack in the range from 16 to 19 degrees. It was demonstrated that the vapor screen technique can be applied successfully to flight vehicles under a variety of test conditions, taking into consideration the transonic maneuver performed by fighter aircraft. Details regarding the employed in-flight flow visualization technique are discussed, taking into account the seeding system, the light sheet system, the video system, the control system, and the recording of the data. Attention is also given to the flight program, the data development, and the scientific observations. G.R.

**A86-32119#**

**CONSTANT ALTITUDE HELICOPTER FLIGHT TESTING**

D. M. LAYTON (Per Safe, Salinas, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 6 p.

(AIAA PAPER 86-9787)

Helicopter performance is evaluated using conventional and constant altitude testing. The equations for induced, profile, parasite, and tail rotor powers, which are needed to sustain a single main rotor helicopter in level, unaccelerated forward flight, are presented; in order to maintain a constant coefficient of power a constant weight/density ratio is required. The relations between fuel consumption, pressure, altitude, temperature, and density ratio values are analyzed. The procedures for the constant altitude technique are described. Light and heavy weight helicopters performance was measured at a constant altitude; accurate density ratio values that correlate well with conventional testing data were obtained. I.F.

**A86-32132#**

**HIGH TECHNOLOGY TEST BED PROGRAM**

C. B. PAYNE (Lockheed-Georgia Co., Marietta) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p.

(AIAA PAPER 86-9803)

The High Technology Test Bed (HTTB) program, initiated in 1984, is concerned with the addition of performance-enhancing design features to a Hercules test aircraft which facilitate Short Takeoff and Landing (STOL) capabilities and generally enhance tactical cargo mission survivability. Advanced electronics, avionics and cockpit designs are incorporated. Attention is given to the 'tactical assault mission' threat scenario which furnishes the context for HTTB design requirements. The new cockpit incorporates a cockpit management system, a HUD, programmable displays, and an autothrottle. A 'Special Avionics Mission Strap-On Now' pod is used to enhance mission adaptability. O.C.

**A86-32133#**

**EXPERIENCE WITH FLIGHT TESTING INTEGRATED AVIONICS SYSTEMS**

F. E. PARLINI and J. R. COMBLEY (Boeing Commercial Airplane Co., Seattle, WA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 6 p.

(AIAA PAPER 86-9804)

The development and testing of the Boeing aircraft integrated digital Flight Management System (FMS) is discussed. On the 747, the INS was followed by the engine thrust limit computer, which led to the Performance Management System, which was then interfaced with the INS, autopilot and autothrottle to provide lateral/vertical navigation FMS capability. Digital avionics follow ARINC 700 and 429 specifications, and include the use of a Mark 33 Digital Information Transfer System. Integrated system testing involves both laboratory testing, including the employment of an engineering flight simulator, and inflight testing, including the use of the PADDS data recording system for troubleshooting on customer aircraft. A flight test bus has also proved useful in providing outputs of internal signals, and a navigation performance program has been developed for data analysis purposes. R.R.

**A86-32134#**

**TORNADO AVIONIC FLIGHT TESTING**

E. PEARSON (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.

(AIAA PAPER 86-9805)

The avionic flight testing of the IDS (interdiction and strike) Tornado, a variable wing, fly-by-wire, multiweapon aircraft capable of treetop penetration in all weather conditions, is described. Following avionic subsystem development, and testing aboard two Buccaneer aircraft, Tornado prototypes were flight tested in England, Germany and Italy. The test reference system for the navigation tests employed a combination of an external surveillance radar and vertical photography with aircraft attitude compensation. Weapon aiming testing used release point assessments, and ballistic constants were measured by kinetheodolite tracking. The terrain following/autopilot-flight director testing objective of 200-ft set clearance height/0.9 Mach flight, was achieved in instrument meteorological conditions in 1985. R.R.

**A86-32137#**

**SPECIFIC EXCESS POWER APPLICATIONS FOR ROTARY WING AIRCRAFT**

C. A. PARLIER (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p. refs

(AIAA PAPER 86-9810)

Traditional rotary wing flight test techniques emphasize basically static performance parameters. As a result, there is a void in the empirical data obtained for helicopters. The lack of dynamic performance data has been highlighted by efforts to increase the fidelity of flight simulation models and smart flight control systems, as well as the pilot's understanding of the maneuvering capability of the aircraft. Specific excess power (Ps) test techniques can be used to partially fill-in the data voids which presently exist. Author

**A86-32138*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**CLOUD PARTICLE EFFECTS ON LAMINAR FLOW IN THE NASA LEFT PROGRAM - PRELIMINARY RESULTS**
R. E. DAVIS, M. C. FISCHER (NASA, Langley Research Center, Hampton, VA), D. F. FISHER, and R. YOUNG (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p. refs
(AIAA PAPER 86-9811)

Laminar flow offers the promise of significant fuel savings on future commercial transport aircraft, but laminar flow can be lost while encountering clouds or haze at cruise conditions. To quantify the effect of cloud particles on laminar flow during typical airline operating conditions, and evaluate candidate cloud particle detection instrument concepts for future laminar flow aircraft, two types of cloud particle detectors are being flown aboard a NASA JetStar aircraft in the Leading Edge Flight Test (LEFT) program. The instrumentation is described, and preliminary results and conclusions are presented. Author

**A86-32143#**
**BIRD IMPACT TESTING AT AEDC'S RANGE S-3**
V. CENTONZE and N. M. SCHMOEKER (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9818)

The considered facilities for bird impact testing consist of three parts, including the driver, the launch tube, and the concrete test pad. The driver has the objective to accelerate the bird to the desired launch velocity. It contains a 31-ft-long chamber with an 8-in.-diameter bore, and a volume of 10.8 cu ft. The launch tube is a 120-ft-long tube comprised of two rigidly mounted sections. A covered concrete test pad, where the target and its associated instrumentation are housed, constitutes the outdoor portion of the range. The test operations are discussed, taking into account the projectile, sabots, sabot strippers, test instrumentation, velocity measurement, deflection measurements, and strain, acceleration, pressure, and temperature measurements. Attention is also given to planned facility improvements, test projects, and aircraft component testing. G.R.

**A86-32147#**
**A NEW RAIN/ICE TEST CAPABILITY TO SIMULATE FLIGHT**
G. R. BEITEL and R. K. MATTHEWS (Calspan Corp., Arnold Air Force Station, TN) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p. refs
(AIAA PAPER 86-9824)

A supersonic rain simulation environment to test the impact of rain and ice on aircraft and missile airframes has been developed. The ice particles are suspended in a liquid nitrogen carrier and injected into the tunnel upstream of the nozzle. During laboratory tests of the injection system, 500-micron ice particles were discharged at rates up to 500,000 particles per sec for durations up to 60 seconds. The characteristics of a particulate cloud prior to impact with the test article were determined using a laser diagnostics system; particle velocities were measured using a laser Doppler velocimeter. A detailed description of the calibration test program for the simulator is given. I.H.

**A86-32776#**
**A REVIEW OF COMPUTER SIMULATIONS FOR AIRCRAFT-SURFACE DYNAMICS**
G. R. DOLE, JR. (Dayton, University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 257-265. USAF-sponsored research. refs

Techniques for the dynamic simulation of aircraft-surface operations are examined. The computer programs are designed to predict gear loads, structural response, and soil behavior for aircraft traversing bomb damage repaired runways or manuevering on soil. The capabilities and limitations of the programs are described. The range of simulation codes from linear, single-degree-of-freedom models to nonlinear three-dimensional models with flexible airframe modes is studied. The validation of the codes is discussed. The use of time-domain analysis to predict catastrophic failure is investigated. I.F.

**A86-32787*#** PRC Kentron, Inc., Hampton, Va.
**NEW AND EXISTING TECHNIQUES FOR DYNAMIC LOADS ANALYSES OF FLEXIBLE AIRPLANES**
A. S. POTOTZKY (PRC-Kentron, Inc., Aerospace Technologies Div., Hampton, VA) and B. PERRY, III (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 651-663) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 340-347. Previously cited in issue 13, p. 1849, Accession no. A85-30394. refs

**A86-33237**
**A NUMERICAL ANALYSIS FOR VERTICAL GUST FIELD INDUCED BY GUST GENERATOR**
Y. YANG and J. WANG (Northwestern Polytechnical University, Xian, People's Republic of China) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 187-193.

This paper presents a calculating method for vertical gust field induced by gust generator which consists of a group of oscillating vanes based on subsonic unsteady lifting surface theory. When the geometry of the gust generator, oscillating frequency and amplitude, Mach number are given, the unsteady downwash field can be determined. In the calculation, the interference among the vanes are considered. Through numerical calculation, the characteristics of the vertical gust field induce by one, two, or three vanes with various reduced frequencies and Mach numbers are investigated. The influence of the gust generator on the characteristics of the vertical gust field are discussed, and some profitable conclusions for gust wind tunnel design are also obtained. Author

**A86-33239**
**EXPERIMENTAL TRANSONIC PRESSURE DISTRIBUTIONS OF A FLEXIBLE WING-AILERON MODEL AND COMPARISONS WITH RESULTS OF SEVERAL THEORETICAL METHODS**
D. GUAN, W. LIU, Z. GAO, and Y. ZHANG (Shenyang Aircraft Corp., People's Republic of China) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 211-218.

Analytical methods for the prediction of transonic load distribution due to large aileron deflection angle on a flexible wing were investigated. A 60-deg delta wing model with representative stiffness level and deflected aileron was tested in a high speed wind tunnel and pressure distributions were measured. Second-order transonic small disturbance theory, linearized aerodynamic theory and an empirical method based on rigid model pressure distributions were used to calculate the load distribution. It seems that the empirical method is more powerful. Author

**A86-33241**
**STATIC AEROELASTIC ANALYSIS USING AIRCRAFT VIBRATION MODES**
Z. SHEENA and M. KARPEL (Israel Aircraft Industries, Ltd., Lod) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 229-232.

A method for the calculation of the airload distribution and aeroelastic effectiveness parameters of a flexible aircraft from the distribution of a rigid one, using its vibration modes, is presented here. The traditional methods of solving problems involving static aeroelasticity use the discrete model of an aircraft. Such a model usually has hundreds of degrees of freedom. The method presented here uses modal data of the model in the form of a limited number of low frequency mode shapes and their associated generalized stiffnesses. The mathematical operations in this case are done on the generalized matrices of the model which have a small number of degrees of freedom. The uniqueness of this method is in its capability to calculate the static aeroelastic properties of a free-free aircraft using its elastic, inertial and aerodynamic properties. Another advantage of this method is that it is suitable for making parametric analyses involving changes in the stiffness of the structure and the aerodynamics of the model. Numerical examples are given and the convergence with the number of modes taken into account is discussed. Author

**A86-33242**

### A REVIEW OF AEROELASTIC RESEARCH AT THE FLIGHT DYNAMICS LABORATORY

T. M. HARRIS, T. E. NOLL, T. J. HERTZ, and W. A. SOTOMAYER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: International Symposium on Aeroelasticity and structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 233-243. refs

Development history and current development status evaluations are conducted for the primary research areas in the field of aeroelasticity that have been investigated by the Flight Dynamics Laboratory of the U.S. Air Force's Wright Aeronautical Laboratories. There areas are: (1) aeroservoelasticity, developing tools for the aeroelastic analysis of aircraft when active feedback control systems are taken into account; (2) adaptive flutter suppression, for aircraft carrying external stores; (3) the effect of external stores carriage on body freedom flutter for forward swept wings; and (4) three-dimensional transonic unsteady aerodynamic codes. O.C.

**A86-33243*** National Aeronautics and Space Administration, Washington, D.C.

### SELECTED TOPICS IN EXPERIMENTAL AEROELASTICITY AT THE NASA LANGLEY RESEARCH CENTER

R. H. RICKETTS (NASA, Material and Structures Div., Washington, DC) IN: International Symposium on Aeroelasticity and structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 244-256. Previously announced in STAR as N85-30364. refs

The results of selected studies that have been conducted by the NASA Langley Research Center in the last three years are presented. The topics presented focus primarily on the ever-important transonic flight regime and include the following: body-freedom flutter of a forward-swept-wing configuration with and without relaxed static stability; instabilities associated with a new tilt-rotor vehicle; effects of winglets, supercritical airfoils, and spanwise curvature on wing flutter; wind-tunnel investigation of a flutter-like oscillation on a high-aspect-ratio flight research wing; results of wing-tunnel demonstration of the NASA decoupler pylon concept for passive suppression of wing/store flutter; and, new flutter testing methods which include testing at cryogenic temperatures for full scale Reynolds number simulation, subcritical response techniques for predicting onset of flutter, and a two-degree-of-freedom mount system for testing side-wall-mounted models. Author

**A86-33244**

### AEROELASTIC WIND TUNNEL SIMILARITY THEORY FOR ANISOTROPIC AIRCRAFT WINGS

G. A. OYIBO (Fairchild Republic Co., Farmingdale, NY) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 257-264. refs

An examination of the fundamental aeroelastic equations of motion for anisotropic aircraft wings, with the help of affine transformations, indicates that a unified aeroelastic simulation theory can be formulated which reduces to the current theory in the isotropic limit. The necessary condition for preserving the Strouhal number between the real aircraft wing and its wind tunnel model is found to lie in the preservation of the generalized forms of the similarity parameters suggested by Theodorsen and Garrick (1940), as well as new parameters reflecting the various directional and coupling stiffness properties of anisotropic materials in a given aerospace structure. The use of these analysis results should significantly improve the understanding of previous wind tunnel data on anisotropic aircraft wings. O.C.

**A86-33245**

### THE CHOICE OF TECHNIQUES USED FOR FLIGHT FLUTTER CLEARANCE WITH PARTICULAR REFERENCE TO THE BAE 146 AND BAE 125

A. G. WOODS (British Aerospace, PLC, Civil Div., Hatfield, England) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 265-275. refs

Decisions must be made during the design of an aircraft regarding the most appropriate flight test method to be used to obtain flight flutter clearance. These decisions must be made in sufficient time to allow for the design and manufacture of test equipment, also for writing and testing the associated analysis programs. This paper discusses the background to the choice of techniques to be used, with special reference to the recently completed flight flutter tests of the BAe 146 feeder liner and the BAe 125 Series 800 executive jet. Details of the chosen methods of excitation, recording and analysis are given for these aircraft, with typical results. Author

**A86-33247**

### EXPERIENCE WITH AEROELASTIC ANALYSIS OF A SINGLE ENGINE TURBO TRAINER USING FINITE ELEMENTS METHODS

M. J. REINICKE, A. S. TURI (Pilatus Aircraft, Ltd., Stans, Switzerland), and A. VOLLAN (Omega GmbH, Immenstaad, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 286-296.

PILATUS' experience with the aeroelastic analysis of a single engine Advanced Turbo Trainer is presented. Thence a aconcept is worked out for current and future applications. The present aeroelastic analysis is based on theoretical approach using finite element methods. Dynamic analysis results are validated by comparison with those from ground vibration tests of a similar structure. MSC/NASTRAN solutions were used for both dynamic and aeroelastic analysis. Rigid Formats were extensively altered to achieve higher flexibility. CPU time requirements were drastically reduced by the use of a NASTRAN DMAP program allowing parametric variation of modal mass, stiffness and damping. Calculated flutter results are compared with those from flight test. Author

**A86-33256**

### THE APPLICATION OF PRACTICAL OPTIMIZATION TECHNIQUES IN THE PRELIMINARY STRUCTURAL DESIGN OF A FORWARD-SWEPT WING

E. LERNER (Grumman Aerospace Corp., Bethpage, NY) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 381-392. refs

In the mid-seventies, a renewed interest in forward-swept wings stemmed from the emergence of advanced composite materials for use in lifting-surface design. At about that same time, investigators in the field of structural optimization were suggesting automated procedures for achieving least-weight designs of surfaces subjected to aeroelastic as well as strength requirements. This paper describes the application of optimization technology in preliminary design studies that preceded the full development of the Grumman X-29, forward-swept-wing, demonstrator aircraft. A review is given of finite-element resizing methods that were developed to satisfy optimality criteria for strength and divergence-velocity constraints. Application of the methods in an initial feasibility study of a variable-sweep wing and, later, in a more-detailed, fixed-wing design study are described. The usefulness of the methodology at various stages of design is demonstrated by tracing the process that led to the selection of an efficient cover-laminate configuration. Author

**A86-33257**
**STRUCTURAL OPTIMISATION PROGRAMS AND METHODS**
A. J. MORRIS (Cranfield Institute of Technology, England) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 393-406. refs

Attention is given to current practices in the CAD generation of minimum weight structure designs. The definition of design variables essentially fixes the form of the objective function; the remainder of the design problem is defined by the constraints limiting the range of values to be taken by the design variables in order to describe a realistic and safe structure. In the case of aircraft, loads are complex and give rise to a nonconservative system, due to the transmission of forces to the structure as a function of the deformed position and the structural/aerodynamic damping. O.C.

**A86-33258**
**VARIATION OF ANISOTROPIC BEHAVIOUR IN STRUCTURAL OPTIMIZATION**
G. HORNUNG, D. W. MATHIAS, and H. ROEHRLE (Dornier GmbH, Friedrichshafen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 407-414.

The 'gradient method' optimization procedure is presented with attention to results obtained by it for the optimization of a laminate composite wing box structure by which all design constraints are satisfied and weight is at its minimum. Prescribed restrictions in this procedure are restraints with respect to the failure of the laminate layers and the minimum thickness of the layers. The first part of the optimization process selects appropriate fiber orientations for a given structure under a given load; the second part improves this configuration by varying layer thicknesses until optimum design is obtained. O.C.

**A86-33259**
**TAILORING METHODOLOGY FOR AEROELASTIC STABILITY AND LATERAL CONTROL ENHANCEMENT**
T. A. WEISSHAAR (Purdue University, West Lafayette, IN) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 415-425. refs

Aeroelastic tailoring introduces directional stiffness into an aircraft structural design to control static or dynamic aeroelastic deformation so that aerodynamic and structural performance is affected in a beneficial manner. Utilization of the tailoring concept is often suggested, but has not been widely applied. This paper illustrates the problems and the potential of aeroelastic tailoring. Passive stability enhancement is shown to involve a compromise since. for fixed-root airfoils, maximizing flutter speed tends to minimize divergence speed and vice versa. Specific examples are included in the paper and involve both forward swept wing (FSW) and aft swept wing configurations. Nondimensional tailoring parameters are identified, independent of actual laminate geometry. The problem of tailoring for lateral control effectiveness is also reviewed for sweptback wings. Author

**A86-33261**
**ANISOTROPIC WING AEROELASTIC THEORIES WITH WARPING EFFECTS**
G. A. OYIBO and J. H. BERMAN (Fairchild Republic Co., Farmingdale, NY) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 434-440. refs

The aeroelastic equivalent of the aerodynamic similarity rule is used in an investigation of the influence of warping (spanwise axial constraints on wing twist) on anisotropic wing aeroelastic oscillations. The results obtained indicate that a high aspect ratio anisotropic wing should behave aeroelastically as a low aspect ratio wing, and vice-versa. Similarity parameters are derived and it is noted that the parameter currently used to determine when warping becomes significant is inaccurate for the case of anisotropic wings. The correct parameter is presented. O.C.

**A86-33263**
**EFFECTS OF ANISOTROPIC DESIGN ON THE STATIC AEROELASTICITY OF A SWEPT WING**
M. PIENING (DFVLR, Institut fuer Strukturmechanik, Brunswick, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 451-456. refs

By exploiting the directional stiffness properties of composite materials coupling between different deformation modes can be achieved. The capability to apply this potential as design parameter is generally known as AEROELASTIC TAILORING. Although the utilization of the tailoring concept is often suggested in the context with the renewed interest in a forward swept wing it is generally applicable to improve the aircraft performance within the flight envelope. A simple structural idealization is adopted to model an arbitrary swept anisotropic wing of moderate to high aspect ratio. The related differential equations are solved for the deformations and internal forces by multiple shooting. The divergence speed is calculated by searching the lowest eigenvalue of the structural matrix formed from the transfer matrices of the wing sections and the according boundary conditions. Some parametric evaluations are performed. Author

**A86-33264**
**AEROELASTIC PROBLEMS AND STRUCTURAL DESIGN OF A TAILLESS CFC-SAILPLANE**
J. SCHWEIGER, O. SENSBURG (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany), and H. J. BERNS (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 457-467. refs

Current structural optimizations programs, such as FASTOP and TSO, are presently applied to the redesign of a carbon fiber-reinforced composite tailless sailplane configuration. These programs obtained optimum reinforcing fiber orientations and stiffness distributions that met both aeroelastic and strength requirements. Flutter speed was doubled as a result of the design changes identified by this work, which encompassed wing root geometry modifications, a new main spar design, and the use of a novel, high modulus fiber type. O.C.

**A86-33267**
**STRUCTURAL DYNAMIC ASPECTS OF ROTOR NODAL ISOLATION**
J. STOPPEL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 486-494.

Attention is given to the practical test results obtained in recent work with the antiresonance isolation system for helicopters designated 'ARIS'; this passive nodal isolation system employs an antiresonant frequency that is tuned to the main rotor passage frequency to prevent the transmission of the oscillatory hub forces and moments to the fuselage. Finite element methods are presently used to model the effectiveness of an ARIS for the case of the BK 117 helicopter. In this way, both eigenvalue analysis and frequency response potential vibration problems can be predicted. O.C.

**A86-33280**
**DETERMINATION OF NATURAL VIBRATION PROPERTIES OF A WING WITH WINGLET BY EXPERIMENTAL MODE SYNTHESIS TECHNIQUE**
S. N. GU, W. J. YOU, and J. S. JIANG (Northwestern Polytechnical University, Xian, People's Republic of China) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 605-611. refs

Electrical measurements and laser time-averaged holographic interferometry supplemented by sand-contour methods are used to determine the nine lowest natural frequencies and their corresponding natural modes on a wing with winglet. The six lowest natural modes of the wing and the three lowest ones of the winglet are orthogonalized, and a three-dimensional quantitative analysis and orthogonalization of the three lowest natural modes are carried out. Also noted are a method for controlling the density of fringes on images reconstructed from the time-averaged holograms, and an analytical method for the orthogonalization of measured modes. O.C.

**A86-33281**
**RAPID VIBRATION MODE ANALYSIS OF AIRCRAFT WITH EXTERNAL STORES**
M. KARPEL (Israel Aircraft Industries, Ltd., Tel Aviv) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 612-616. refs

**N86-22563*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**COMPARISON OF MEASURED AND CALCULATED TEMPERATURES FOR A MACH 8 HYPERSONIC WING TEST STRUCTURE**
R. D. QUINN and R. A. FIELDS Mar. 1986 140 p refs
(NASA-TM-85918; H-1271; A-85137; NAS 1.15:85918) Avail: NTIS HC A07/MF A01 CSCL 01C

Structural temperatures were measured on a hypersonic wing test structure during a heating test that simulated a Mach 8 thermal environment. Measured data are compared to design calculations and temperature predictions obtained from a finite-difference thermal analysis. Author

**N86-22564#** Department of the Air Force, Washington, D.C.
**AIRCRAFT WINDOW CLAMPING DEVICE Patent Application**
J. H. DEOMS, inventor (to Air Force) 16 Oct. 1985 13 p
(AD-D011999; US-PATENT-APPL-SN-788189) Avail: NTIS HC A02/MF A01 CSCL 13E

An aircraft window clamping ring is used to hold an optical sensor window against an aircraft wall. The ring has a plurality of cantilevers having upper contacts that bear directly down on the window. Because of the flexibility in the vertical direction, thermal expansion is compensated for by movement of the cantilevers. Horizontal expansion of the window creates no additional stress because the upper contacts bear perpendicular to possible horizontal movement. The cantilevers can be designed to preload the window to take into account maximum thermal expansion. Author (GRA)

**N86-22565#** Joint Publications Research Service, Arlington, Va.
**USSR REPORT: TRANSPORTATION**
12 Mar. 1986 92 p Transl. into ENGLISH from various Russian articles
(JPRS-UTR-86-004) Avail: NTIS HC A05/MF A01

Transportation issues in the Soviet Union are reported. Topics discussed include: civil aviation, rail systems, maritime and river fleets, ports and transshipment centers, and intersector network development.

**N86-22567#** Joint Publications Research Service, Arlington, Va.
**MORE ON NEW IL-96, IL-114 AIRCRAFT**
V. INOZEMTSEV *In its* USSR Report: Transportation (JPRS-UTR-86-004) p 9-11 12 Mar. 1986 Transl. into ENGLISH from Nedelya (Moscow, USSR), no. 46, 11-17 Nov. 1985 p 8
Avail: NTIS HC A05/MF A01

The development of the Ilyushin Aircraft IL-96, the long range Russian airbus, is discussed. The airbus is reminescent of the IL-86, however, its dimensions are larger and the wing span is almost 10 m greater, and the tail fin is 2 m higher. The IL-96 is a two-decked aircraft, which can hold 300 passengers. The lower deck houses 15 standard baggage handling containers. The IL-96-300 is designed to make long flights, with two or three landings in a day. The design of the 60 seat IL-114 passenger turboprop is also described. Its cruising speed is 500 km/hr, and has two multiblade gas turbine engines. It has high aircraft efficiency. It has built-in ramps. It serves short and medium distances. E.A.K.

**N86-22568#** Joint Publications Research Service, Arlington, Va.
**TUPOLEV BUREAU DEVELOPING TU-204 PASSENGER JET: TUPOLEV ON FEATURES**
A. A. TUPOLEV and N. DOMBKOVSKIY *In its* USSR Report: Transportation (JPRS-UTR-86-004) p 12-16 12 Mar. 1986 Transl. into ENGLISH from Trud (Moscow, USSR), 3 Jan. 1986 p 4
Avail: NTIS HC A05/MF A01

The design and development of the TU-204 passenger jet is discussed. The latest methods in aerodynamics, engine construction, materials science and manufacturing were incorporated in the design. The cabin has more comfortable seats and wider aisles, and the aircrafts can carry 124 passengers. The TU-204 will replace the TU-154 passenger transport plane. The plane has an on-board computer system which will reduce the number of crew members to two or three. E.A.K.

**N86-22569#** Joint Publications Research Service, Arlington, Va.
**DETAILS OF NEW KA-126 HELICOPTER**
I. ANDREYEV *In its* USSR Report: Transportation (JPRS-UTR-86-004) p 17-19 12 Mar. 1986 Transl. into ENGLISH from Izvestiya (Moscow, USSR), 29 Jan. 1986 p 1
Avail: NTIS HC A05/MF A01

The development and construction of the Ka-126 agricultural helicopter is discussed. The Ka-126 is a modification of the older Ka-26 helicopter. The helicopter is equipped with one gas-turbine engine and its characteristics are enumerated. The economy and profitability of the helicopter are outlined. The Ka-126 is not influenced by low temperatures so that is can be utilized during the winter months. E.A.K.

**N86-22570#** Joint Publications Research Service, Arlington, Va.
**CHINA REPORT: SCIENCE AND TECHNOLOGY**
20 Feb. 1986 59 p refs Transl. into ENGLISH from various Chinese articles
(JPRS-CST-86-007) Avail: NTIS HC A04/MF A01

Progress in science and technology in the People's Republic of China is reported. Topics discussed include research and development in: computer sciences, applied sciences, acoustics, electronics, physics, and radiation protection.

**N86-22572#** Joint Publications Research Service, Arlington, Va.
**IMPROVED Y-7, Y-12 AIRCRAFT DESCRIBED**
S. BU *In its* China Report: Science and Technology (JPRS-CST-86-007) p 27-29 20 Feb. 1986 Transl. into ENGLISH from Hangkong Zhishi (Beijing, China), no. 12, Dec. 1985 p 3
Avail: NTIS HC A04/MF A01

The improved designs of the Y-7 and Y-12 aircrafts are described. The electronic equipment on the Y-7 was converted. The equipment included: environmental control system, atmospheric data system, ultrashortware radio station, magnetic navigation reference and attitude reference system, Omega navigation system, weather radar, guidance system, ranging device, and bearing receiver. The noise level was reduced. The interior of the Y-12 was changed and noise and vibration were reduced. The exterior was coated with high quality paint. E.A.K.

**N86-22573#** Joint Publications Research Service, Arlington, Va.
**DETAILS OF Y-121 STOL AIRCRAFT PRESENTED**
Z. SONG *In its* China Report: Science and Technology (JPRS-CST-86-007) p 30-32 20 Feb. 1986 refs Transl. into ENGLISH fdrom Hangkong Zhishi (Beijing, China), no. 12, Dec. 1985 p 4-5
Avail: NTIS HC A04/MF A01

The Y-121 is a newly developed, twin-engine turboprop, short take-off and landing multifunction airplane. It can be used for transportation, parachuting and for various applications in geology, agriculture and forestry; it can also be converted into a special-purpose airplane for precision search operation. The development design features, and technical performance of the Y-121 STOL aircraft are described. E.A.K.

**N86-23585** Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).
**STANDARDIZED FATIGUE LOADING SEQUENCES FOR HELICOPTER ROTORS (HELIX AND FELIX). PART 1: BACKGROUND AND FATIGUE EVALUATION. PART 2: FINAL DEFINITION OF HELIX AND FELIX**
D. SCHUETZ, H. G. KOEBLER, W. SCHUETZ (Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn, West Germany), M. HUECK (Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn, West Germany), J. B. DEJONGE (NLR, Emmeloord, Netherlands), A. A. TENHAVE (NLR, Emmeloord, Netherlands), F. OCH (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, West Germany), G. DASKE (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, West Germany), P. R. EDWARDS, comp. (RAE, Farnborough, England), J. DARTS, comp. (RAE, Farnborough, England) et al. 1985 235 p refs
Sponsored by Bundesministerium fuer Forschung und Technologie
(LBF-FB-167; IABG-TF-1425/1; IABG-TF-1425/2; NLR-TR-84043-U-PT-1; NLR-TR-84043-U-PT-2; RAE-TR-84084; RAE-TR-84085; ISSN-0721-5320) Avail: Issuing Activity

The Helix and Felix standard loading sequences for the main rotors of helicopters with articulated and semirigid rotors respectively are described. The definition of Helix and Felix, statistical content according to different counting methods, and the results of fatigue tests used to assess them are outlined. The defined form of the two standards is given in full length and shortened versions. The method of generation is extremely simple, although a considerable amount of data is required for the generation algorithm. A FORTRAN program for this purpose, together with complete data tables in the correct format, are presented. Author (ESA)

**N86-23586*#** Lightning Technologies, Inc., Pittsfield, Mass.
**LIGHTNING PROTECTION GUIDELINES AND TEST DATA FOR ADHESIVELY BONDED AIRCRAFT STRUCTURES Final Report**
J. E. PRYZBY and J. A. PLUMER Washington NASA Jan. 1984 175 p refs
(Contract NAS1-15884)
(NASA-CR-3762; NAS 1.26:3762; LT-83-155) Avail: NTIS HC A08/MF A01 CSCL 01C

The highly competitive marketplace and increasing cost of energy has motivated manufacturers of general aviation aircraft to utilize composite materials and metal-to-metal bonding in place of conventional fasteners and rivets to reduce weight, obtain smoother outside surfaces and reduce drag. The purpose of this program is protection of these new structures from hazardous lightning effects. The program began with a survey of advance-technology materials and fabrication methods under consideration for future designs. Sub-element specimens were subjected to simulated lightning voltages and currents. Measurements of bond line voltages, electrical sparking, and mechanical strength degradation were made to comprise a data base of electrical properties for new technology materials and basic structural configurations. The second hase of the program involved tests on full scale wing structures which contained integral fuel tanks and which were representative of examples of new technology structures and fuel systems. The purpose of these tests was to provide a comparison between full scale structural measurements and those obtained from the sub-element specimens. Author

**N86-23587*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**MINIMUM TIME AND FUEL FLIGHT PROFILES FOR AN F-15 AIRPLANE WITH A HIGHLY INTEGRATED DIGITAL ELECTRONIC CONTROL (HIDEC) SYSTEM**
E. A. HAERING, JR. and F. W. BURCHAM, JR. Jun. 1984 25 p refs
(NASA-TM-86042; H-1242; NAS 1.15:86042) Avail: NTIS HC A02/MF A01 CSCL 01C

A simulation study was conducted to optimize minimum time and fuel consumption paths for an F-15 airplane powered by two F100 Engine Model Derivative (EMD) engines. The benefits of using variable stall margin (uptrim) to increase performance were also determined. This study supports the NASA Highly Integrated Digital Electronic Control (HIDEC) program. The basis for this comparison was minimum time and fuel used to reach Mach 2 at 13,716 m (45,000 ft) from the initial conditions of Mach 0.15 at 1524 m (5000 ft). Results were also compared to a pilot's estimated minimum time and fuel trajectory determined from the F-15 flight manual and previous experience. The minimum time trajectory took 15 percent less time than the pilot's estimate for the standard EMD engines, while the minimum fuel trajectory used 1 percent less fuel than the pilot's estimate for the minimum fuel trajectory. The F-15 airplane with EMD engines and uptrim, was 23 percent faster than the pilot's estimate. The minimum fuel used was 5 percent less than the estimate. Author

**N86-23588*#** Computer Sciences Corp., Hampton, Va.
**IMPROVEMENTS TO THE FATOLA COMPUTER PROGRAM INCLUDING ADDED ACTIVELY CONTROLLED LANDING GEAR SUBROUTINES Final Report**
G. H. MALL Apr. 1983 217 p
(Contract NAS1-16078)
(NASA-CR-166069; NAS 1.26:166069; TAO-33842) Avail: NTIS HC A10/MF A01 CSCL 01C

Modifications to a multi-degree-of-freedom flexible aircraft take-off and landing analysis (FATOLA) computer program, including a provision for actively controlled landing gears to expand the programs simulation capabilities, are presented. Supplemental instructions for preparation of data and for use of the modified program are included. Author

**N86-23589#** Hover Systems Federal Corp., Eddystone, Pa.
**AFTER ACTION REPORT, CH-47 RECOVERY USING D-PAAC Report, 13 - 21 Jul. 1985**
Jul. 1985 29 p
(Contract DAAK70-85-C-0014)
(AD-A161935) Avail: NTIS HC A03/MF A01 CSCL 13B

On 12 July 1985, a request was made for use of the D-PAAC in a recovery operation for a crashed CH-47D, which had crashed in a fish and wildlife management area on the New Jersey shore near the Delaware river. Recovery operations were to be conducted with minimal damage to the environment and as quickly as possible. This report will cover the period from 13 to 21 July and will address the period in three sections. The first will cover preparation and movement from Duck, N.C., to Chester, Pa. The second will cover preparation at Chester, Pa., and movement to the crash site. The third will cover operations at the crash site and movement out of the area. The D-PAAC operated on cushions at all times. the concept of using air cushion craft for heavy lift recovery operations in terrain which offers no other accessibility was partially validated. Also, the feasibility of towing an air cushion vehicle over water by conventional tug in an inland waterway operation was proven. It must also be concluded that improved propulsion means are required as well as some self-recovery capability (on-board winch) to improve useability of future craft similiar to the D-PAAC. GRA

**N86-23590#** Naval Research Lab., Washington, D. C.
**ELECTROSTATIC CHARGING OF THE CH-53E HELICOPTER**
R. E. PECHACEK, J. R. GREIG, D. P. MURPHY, and J. SPELZ
29 Nov. 1985 48 p
(Contract F41-411)
(AD-A161936; NRLMR-5676) Avail: NTIS HC A03/MF A01
CSCL 01C

The effects of electrostatic charging on the CH-53E helicopter were examined. Measurements were made over a clean runway and over sandy terrain in basically desert conditions where electrostatic charging is known to be a problem. While the measured charging current (up to approx. 75 microAmp) and open circuit voltages (up to approx. 140 kV) cannot be claimed as maximum values attainable by the CH-53E, they show that the CH-53E is affected by electrostatic charging in much the same way as all other helicopters. Furthermore the range of data recorded in these tests has allowed us to formulate a model for the electrostatic charging of a hovering helicopter in both clean air and sandy air situations. This model is consistent with our own data and recorded prior experience with electrostatic charging of helicopters. It predicts that the CH-53E can readily attain short circuit currents of approx. 300 microAmp and open circuit voltages of approx. 400 kV. GRA

**N86-23591#** Army Science Board, Washington, D.C.
**THE US ARMY'S LHX (LIGHT HELICOPTER FAMILY) PROGRAM Final Report, 1983 - 1984**
W. L. HARRIS, J. BLAIR, G. F. DECKER, and R. L. MCDANIEL
Dec. 1984 50 p
(AD-A161949) Avail: NTIS HC A03/MF A01 CSCL 01C

Observations, analysis, conclusions and recommendations of the AHSG on selected critical issues related to the Army's LHX aircraft program are described. The basis of LHX, LHX program management, technology risk assessment, speed, and one versus two-man flight crew are discussed in the initial sections of this report. These issues constitute the more fundamental aspects of the Army's LHX program which were reviewed by the AHSG. Primary and secondary conclusions and recommendations are presented. Finally, a discussion of specific technologies and Army aviation programs is given in the appendices to this report. The discussion of each of these technologies and programs includes the AHSG's recommendations and conclusions on the same. A set of attachments follows the appendices. GRA

**N86-23593#** Naval Postgraduate School, Monterey, Calif.
**A SYSTEMS ENGINEERING METHODOLOGY FOR THE ADVANCED TACTICAL AIRCRAFT M.S. Thesis**
S. J. KAPURCH Sep. 1985 89 p
(AD-A162049) Avail: NTIS HC A05/MF A01 CSCL 05A

The increasing specialization of the aerospace industry coupled with the technical complexity of new systems has caused emphasis to be placed on a systematic and logical methodology to design, develop, and produce new products. A systems engineering model to integrate functional management areas with organizational activities in the Advanced Tactical Aircraft program is presented. Special emphasis is placed in applying this systems approach throughout the life cycle of a project. A general methodology and a synopsis of principles are provided which might be utilized in the development of a systems engineering program. GRA

**N86-23594#** Sikorsky Aircraft, Stratford, Conn. Sikorsky Aircraft Div.
**ADVANCED TECHNOLOGY HELICOPTER LANDING GEAR PRELIMINARY DESIGN INVESTIGATION Final Report, 1983 - 1984**
D. LOWRY Oct. 1985 135 p
(Contract DAAK51-83-C-0040; DA PROJ. 1L1-62209-AH-76)
(AD-A162097; SER-510148; USAAVSCOM-TR-85-D-4) Avail:
NTIS HC A07/MF A01 CSCL 01C

A preliminary design investigation has been performed to develop weight and cost sensitivities of various landing gear systems for a 10,000-pound class LHX helicopter. Weights are established for three baseline main landing gear systems: a noncrashworthy retractable, a crashworthy retractable, and a crashworthy fixed. Each system is capable of kneeling the LHX helicopter. Weights are based on preliminary structural analysis of landing gear loads developed by a computer program KRASH. KRASH was used to obtain the design loads at various sink rates, and pitch and roll attitudes. The design loads were used to size the landing gear structure in order to develop the landing gear weight for the different impact conditions. Main landing gear system costs are developed from the weight data established. An aerodynamic drag assessment was performed. Criteria for crashworthy designs are recommended. The recommended criteria were developed from the weight trends, costs, and UH-60A Class A Mishaps. GRA

**N86-23595#** Sverdrup Technology, Inc., Arnold Air Force Station, Tenn.
**ANALYSIS AND VERIFICATION OF THE ICING SCALING EQUATIONS. VOLUME 1 Final Report, 1 Aug. 1981 - 31 Mar. 1984**
G. A. RUFF Nov. 1985 80 p Sponsored by Air Force
(AD-A162226; AEDC-TR-85-30-VOL-1) Avail: NTIS HC A05/MF A01 CSCL 17B

The formation of ice on aircraft surfaces occurs during flight through supercooled droplets. Ice accretions on these surfaces usually degrade both aircraft performance and operational safety. For this reason, it has become important in the design and certification phases of system development to evaluate system performance degradation because of icing. A research program was conducted to evaluate the icing scaling requirements. The objectives of the study were (1) to evaluate the equations governing the icing process to identify proposed scaling parameters, (2) to develop a computer code to solve the various forms of the icing scaling equations, (3) to conduct tests to determine which, if any, of the proposed methods produced scale ice accretions, and (4) if an accurate set of icing scaling equations were found, to write a final computer code that could be used in icing tests. The scaling verification tests were conducted using full and half-scale circular cylinders and full, 1/3, and 1/6-scale airfoil sections. GRA

**N86-23774#** Joint Publications Research Service, Arlington, Va.
**ROLLOUT OF XT-4 INTERMEDIATE CLASS TRAINING AIRCRAFT**
*In its* Japan Report: Science and Technology (JPRS-JST-86-007) p 1-5 25 Mar. 1986 Transl. into ENGLISH from Aerospace Japan (Tokyo, Japan), Jun. 1985 p 31-33
Avail: NTIS HC A04/MF A01

The completion of an XT-4 intermediate class training aircraft is reported. The XT-4 is a high-performance training aircraft produced entirely in Japan. The work of matching its engine and airframe will begin and the airframe will be subjected to functional tests. It will then be subjected to in-house tests and it will be delivered to the Defense Agency and tested for 2 years. Its scheduled completion is set for 2 years. The XT-4 has excellent flight characteristics at a wide variety of speeds. It is equipped with transonic wings, and the airframe shape is modified. The XT-4 is a training aircraft, and is scheduled to be used for flight training, however, it is an excellent aircraft with performance and characteristics suitable for Japan's needs. It is outstanding for rate of climb and range performance. E.A.K.

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-29864#**
**EVALUATION OF FORMATS FOR AIRCRAFT CONTROL/DISPLAY UNITS**
T. L. MANN and L. A. LEIKER (Lockheed-Georgia Co., Marietta) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 135-142. refs

In this preliminary study of the definition of an optimal control/display unit display format design which will ensure effective and efficient human performance in the cockpit environment, subjects visually searched alphanumeric displays for a single unit of information and indicated when it was found. Data was thus collected on the accuracy of information retrieval, as well as the elapsed time to isolate the information; ten formats of two information densities each were evaluated, each of which contained labels and associated data for typical flight data and communications data. The results obtained indicate that both format design and density affect operator response time and accuracy. Implications of these findings are discussed. O.C.

**A86-30312#**
**FLUIDIC GYRO SYSTEMS**
T. B. TIPPETTS (Garrett Corp., Garrett Pneumatic Systems Div., Tempe, AZ) IN: Symposium Gyro Technology 1985; Proceedings of the Symposium, Stuttgart, West Germany, September 24, 25, 1985 . Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1985, p. 13.0-13.51. refs

Fluidic gyroscopic technology can operate under conditions so severe as to prohibit any alternative form of stability augmentation; it, in addition, possesses reliability, storability, and cost benefits over those alternatives that render it applicable to low cost strap-on systems for bombs, direct fire rockets, etc. Fluidic gyros are both EMI- and EMP-proof. Fluidic gyro output signals can be processed by fluidic amplifier, resistor and capacitor circuits, all of which are immune to EMP. Attention is given to applications, sensor operating principles, construction methods, and fluidic amplification/dynamic processing circuits. O.C.

**A86-30315#**
**A LASER-INERTIAL AIRBORNE SURVEYING SYSTEM**
J. W. HURSH (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Symposium Gyro Technology 1985; Proceedings of the Symposium, Stuttgart, West Germany, September 24, 25, 1985 . Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1985, p. 17.0-17.23. refs

The recently developed Aerial Profiling of Terrain System (APTS) furnishes terrain profiling and other survey data at current accuracy standards and with substantial savings in time and field work. APTS incorporates a three-gimbaled inertial platform to indicate aircraft position in three coordinates; a two-axis laser tracker mounted on a common base acquires and follows prelocated retroreflectors in sequence, thereby supplying range and pointing data to update the navigation on the basis of ground truth. The laser profiler provides terrain clearance measurements which are combined with the highly accurate position data from the navigation, in postflight data reduction, to obtain ground profiles. Attention is given to the considerations that most influenced system configuration, as well as the design and fabrication of the APTS hardware. O.C.

**A86-31343**
**AIRBORNE RADAR - THE GREATER WATERSHED**
J. PELLANDINI Interavia (ISSN 0020-5168), vol. 41, March 1986, p. 263, 265.

Three major combat aircraft radar development efforts are currently underway in France: (1) 'RDM', a multifunction, multimode pulse Doppler radar that is fully digital and monopulse, and which employs a frequency-agile coherent transmitter to accomplish many different missions; (2) 'RDI', a pulse Doppler radar optimized for long range interception of oncoming targets at any altitude; and (3) 'Antilope 5', which is designed to allow either simultaneous or separate mapping and terrain following in low altitude penetration missions in all weathers. The present evaluation of these technologies gives attention to methods for the circumvention of electronic countermeasures through ever increasing processing rates for ever increasing quantities of data. O.C.

**A86-32099#**
**INSTRUMENTATION OF A LIGHT TWIN AIRCRAFT FOR FLOW ENERGIZER FLIGHT TESTS**
D. T. WARD and R. S. BINFORD (Texas A&M University, College Station) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 15 p. refs
(AIAA PAPER 86-9759)

Flow energizers represent small lifting surfaces which are added to an aircraft with the objective to alter local flow characteristics. Typically, flow energizers are simpler to manufacture than the fillets, fairings and cuffs which they replace. The present paper is concerned with flow energizers which involve very low aspect ratio configurations, usually having a highly swept leading edge of approximately 75 degrees. Attention is given to pressure port locations on the wind tunnel model, flow energizer terminology, basic flight instruments, angle of attack and sideslip angle, surface pressure instrumentation, wake flow field instrumentation, force and moment instrumentation, integration of instrumentation, pressure data results, wake survey results, and force and moment results. G.R.

**A86-32126#**
**THE NDS 2000 FLIGHT TEST INSTRUMENTATION SYSTEM IN THE F-20 TIGERSHARK**
B. DEMO (Northrop Corp., Hawthorne, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9797)

Northrop Flight Test has developed a modular, distributed, airborne data acquisition system, incorporating several unique technological advances. These include: digital signal processing of analog measurands; self-contained reference junction compensation and integrating A to D conversion for thermocouples; a module to embed compressed digitized voice in the data stream; and a flexible and powerful MIL-STD-1553 bus interface. Author

**A86-32128#**
**AFFTIS - WHAT NOW?**
M. F. LAMY (SCI Technology, Inc., Huntsville, AL) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9799)

The 'AFFTIS' flight test instrumentation system was developed after January of 1983 in order to meet the requirements of a standardized approach to aircraft flight test program data acquisition requirements. Although AFFTIS was cancelled in September of 1985, a number of prepossessing technologies and system concepts were developed by the time of termination; it is to these that attention is presently given. Design details and performance projections are presented for the AFFTIS 10-Mbit full duplex serial bus, the AFFTIS System Controller's programmable secondary outputs and integral data processor, data acquisition units, signal conditioning, and ground and laboratory support systems. O.C.

**A86-32140#**
**AIRBORNE INFRARED MEASUREMENT SYSTEMS AND TECHNIQUES**
W. G. KULLER and M. E. STEBLIN (USAF, Eglin AFB, FL) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p. refs
(AIAA PAPER 86-9814)

Information regarding aircraft infrared signatures is now needed in the design of new weapon systems, and the determination of such signatures requires the conduction of measurements with airborne infrared instrumentation. This paper provides information regarding available airborne systems needed by the test community, taking into account the various test techniques used to employ them. Attention is given to the beam approach seeker evaluation system (BASES), a supersonic airborne infrared measurement system (SAIMS), upgrades to BASES, the Infrared Calibrated Airborne Spatial Measurement System (IR CASMS), a SAIMS upgrade, and the self-contained airborne system ASIMS. In a description of test techniques, aircraft/drones are considered along with flares, missile performance, countermeasures, end-game tracking, and the determination of seeker acquisition envelopes. G.R.

**A86-32144#**
**F-16 FLUTTER TESTING AT EGLIN AIR FORCE BASE**
C. A. DREYER and D. L. SHOCH (USAF, Eglin AFB, FL) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9819)

As combat aircraft reach higher operational limits, while incorporating lighter and less rigid materials in their structures, flutter testing assumes greater importance. Attention is presently given to the flutter flight testing program conducted for the F-16 fighter at the U.S. Air Force's Eglin Air Force Base Armament Division. The tests were conducted with external stores in order to establish external store carriage limits. The instrumentation installed in the test aircraft and the premission calibration procedures required to insure accuracy in the data obtained are described, together with the means by which external stores are instrumented. O.C.

**N86-22574*#** Charles River Analytics, Inc., Cambridge, Mass.
**A PRELIMINARY DESIGN FOR FLIGHT TESTING THE FINDS ALGORITHM Final Report**
A. K. CAGLAYAN and P. M. GODIWALA Mar. 1986 85 p refs
(Contract NAS1-17719)
(NASA-CR-178043; NAS 1.26:178043; R8602) Avail: NTIS HC A05/MF A01 CSCL 01D

This report presents a preliminary design for flight testing the FINDS (Fault Inferring Nonlinear Detection System) algorithm on a target flight computer. The FINDS software was ported onto the target flight computer by reducing the code size by 65%. Several modifications were made to the computational algorithms resulting in a near real-time execution speed. Finally, a new failure detection strategy was developed resulting in a significant improvement in the detection time performance. In particular, low level MLS, IMU and IAS sensor failures are detected instantaneously with the new detection strategy, while accelerometer and the rate gyro failures are detected within the minimum time allowed by the information generated in the sensor residuals based on the point mass equations of motion. All of the results have been demonstrated by using five minutes of sensor flight data for the NASA ATOPS B-737 aircraft in a Microwave Landing System (MLS) environment. Author

**N86-22575#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
**COMPARATIVE EVALUATION OF REDUNDANT FLIGHT DATA RECORDED BY A DIGITAL AIRBORNE INTEGRATED DATA SYSTEM RECORDER (DAR) ON BOARD AN AIRBUS A-310 AIRCRAFT**
O. WEBER and G. ROSENAU 1985 42 p refs
Avail: NTIS HC A03/MF A01

Flight data collected during scheduled Airbus A-310 flights by a Digital AIDS Recorder (DAR) were analyzed. The characteristics of the standard A-310 AIDS are compared to those of the A-300 AIDS. The A-310 reconstruction of the motion state of the aircraft is more complete than with the older equipment. The DAR A-310 permits a detailed and extensive check of the basic AIDS measuring channels through independently measured quantities. This check, however, is restricted to the measuring ranges encountered in normal flight conditions. It cannot be extrapolated to extreme flight conditions expected in accidents or incidents. In the flight conditions of the scheduled flights, the correspondence between basic AIDS measurements and quantities from the extended AIDS is very good. Author (ESA)

**N86-23596#** Air Force Human Resources Lab., Brooks AFB, Tex.
**LOGISTICS ENGINEERING ANALYSIS TECHNIQUES FOR FAULT-TOLERANT AVIONICS SYSTEMS Final Report, Mar. 1982 - Mar. 1984**
J. C. MCMANUS Nov. 1985 59 p
(Contract F33615-82-C-0002)
(AD-A161981; AFHRL-TR-84-60) Avail: NTIS HC A04/MF A01 CSCL 01D

A technique which performs reliability, supportability, and survivability (RSS) analysis of fault-tolerant, dynamically reconfigurable systems during early design is presented. Implemented in the MIssion REliability Model (MIREM) computer program, this method analyzes the structure of functional components in a system. Use of MIREM will allow design engineers to apply RSS analysis before the design is fixed. GRA

# 07

# AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-30093**

### SHORT CRACK PROBLEMS IN GAS TURBINE DISKS

J. DREXLER and J. STATECNY (Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia) IN: Advances in fracture research (Fracture 84). Volume 5 . Oxford and New York, Pergamon Press, 1986, p. 3541-3547.

Methods of detecting a short crack at its first occurrence are described. The crack detection ability level of a human operator is evaluated. The probability characteristics of short cracks are discussed; an example displaying the probability of detecting a short crack at its first occurrence in a blade fir-tree attachment of a gas turbine disk is presented. The estimation of life gain to safe crack occurrence, based on the equation of Nemec and Dexler (1984), is examined and an example is provided. I.F.

**A86-30737#**

### MODELLING AN AXIAL FLOW COMPRESSOR IN STARTING OF A TURBOJET ENGINE

D. YAN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Oct. 1985, p. 467-473. In Chinese, with abstract in English. refs

A method of modelling an axial-flow compressor in low speed starting regime from windmilling to idling of an engine is presented. A structural formula for the model is established according to Deyou (1983). A method of step-by-step regression is proposed for determining the coefficient matrices of the structural formula. The coefficient functions are determined on the basis of the square, linear, and constant terms of the mass flow coefficient respectively in the mathematical model, while in each portion of the regression the rotor speed is considered to approach zero due to the feature of very low speeds. In results the model represents the performance of the compressor at low speeds very well. Good agreement is obtained between the computational and experimental results. Author

**A86-30740#**

### EXPERIMENTAL INVESTIGATION ON FREQUENCY RESPONSE OF A TURBOJET ENGINE TO TURBULENCE-TYPE DYNAMIC DISTORTION

S. LIU, F. CHEN, W. LI, Z. WANG, and M. CONG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Oct. 1985, p. 484-488. In Chinese, with abstract in English.

The inlet and exit fluctuating pressure signals of a compressor prior to 'drift surge' are investigated by correlation and spectral analyses. It is found that the stochastic process of fluctuating pressure is no longer stationary near the inception of the 'drift surge'. The surge of the tested engine under the dynamic distortion is caused by rotating stall. The whole unsteady operating time for the engine to approach surging is about 5 seconds and the process is characterized by rotating stall cell spreading forward from the rear stage over the whole annular passage of the compressor. It is worth noticing that the tested engine is sensitive to pressure fluctuations with certain frequencies prior to the surge, but a strict conclusion needs further experimental investigation. Author

**A86-31328#**

### HOW TO NOT EAT YOUR OWN DUST

B. FRISCH Aerospace America (ISSN 0740-722X), vol. 24, Feb. 1986, p. 18, 19.

Design techniques useful for configuring particle filters for turbine engine air intakes are discussed and illustrated with descriptions of hardware in use or under development. Inertial particle separators have shown promise for the best, and most acceptable, performance in terms of low maintenance, effectiveness and ease of deicing. Vaneless separators (VS) in particular also feature reduced erosion, weight and part count. Contoured walls direct incoming particles to a scavenger duct in VSs when the flow has to accelerate over a hump, then turn. Because of inertia the particles cannot make the turn and are thus scavenged in the direction they must take. CFD/CAD codes which encompass the separator geometry, flow characteristics and particle trajectories are being applied in designing VSs, which are now primarily of interest for the LHX helicopters. M.S.K.

**A86-31349**

### BATTLE OF THE HUSHKITS - ALL QUIETER ON WESTERN FRONT

P. TURK Interavia (ISSN 0020-5168), vol. 41, March 1986, p. 311-314.

A development and implementation status evaluation is made of engine noise reduction technologies aiming at compliance with the FAA's FAR 36 noise level standards for older airliners' powerplants. The 'hushkits' that have been developed for high bypass turbofan engines incorporate acoustic lining materials employing microporous mesh, a metallic perforated plate, a metallic honeycomb structure, and a metallic solid back skin. DC-8 and B-707 airliners have been the primary recipients of these treatments; it has been found that substantially different hushkit designs must be developed for every on of the engine-type/airframe combinations encountered in service. O.C.

**A86-31586#**

### LONGITUDINAL COMBUSTION INSTABILITIES IN RAMJET ENGINES IDENTIFICATION OF ACOUSTIC MODES

J. E. CRUMP, K. C. SCHADOW (U.S. Navy, Naval Weapons Center, China Lake, CA), V. YANG, and F. E. C. CULICK (California Institute of Technology, Pasadena) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Mar.-Apr. 1986, p. 105-109. refs
(Contract AF-AFOSR-80-0265; AF TASK A3103100)

Longitudinal combustion instabilities in liquid-fueled ramjet engines have been investigated with attention focused on determination of the acoustic mode structures. Detailed pressure measurements, including both amplitude and phase, were made at ten positions spanning the length of the engine. The experimental data have been analyzed using two linear acoustic models. Four distinct modes were observed for various inlet/combustor combinations. These results help identify the mechanisms exciting low-frequency pressure oscillations in ramjet engines. Author

**A86-31595*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### AERODYNAMIC AND STRUCTURAL DETUNING OF SUPERSONIC TURBOMACHINE ROTORS

D. HOYNIAK (NASA, Lewis Research Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 500-514) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Mar.-Apr. 1986, p. 161-167. Previously cited in issue 13, p. 1850, Accession no. A85-30378. refs

**A86-32120*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### THE NASA MODERN TECHNOLOGY ROTORS PROGRAM

M. E. WATTS and J. L. CROSS (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 13 p. refs
(AIAA PAPER 86-9788)

Existing data bases regarding helicopters are based on work conducted on 'old-technology' rotor systems. The Modern Technology Rotors (MTR) Program is to provide extensive data bases on rotor systems using present and emerging technology. The MTR is concerned with modern, four-bladed, rotor systems presently being manufactured or under development. Aspects of

MTR philosophy are considered along with instrumentation, the MTR test program, the BV 360 Rotor, and the UH-60 Black Hawk. The program phases include computer modelling, shake test, model-scale test, minimally instrumented flight test, extensively pressure-instrumented-blade flight test, and full-scale wind tunnel test. G.R.

**A86-32121#**

### VERIFICATION OF THE THRUST AND AIRFLOW MODEL OBTAINED FROM THE PERFORMANCE MODELLING PROCESS

J. L. JORDAN and W. G. SCHWEIKHARD (Kohlman Systems Research, Inc. Lawrence, KS) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9790)

This paper demonstrates that the performance modeling method produces an engine performance model which compares faavorably with a calibrated engine deck produced by the manufacturer for a specific engine. An analysis shows that the employment of a thrust run corrected nominal engine model as a basis for a performance analysis represents a viable method. Attention is given to details concerning the engine modeling process, the calibrated engine process, the performance modeling process, ground static thrust runs, and flight test comparisons. G.R.

**A86-32956*#** United Technologies Research Center, East Hartford, Conn.

### DYNAMIC CHARACTERISTICS OF AN ASSEMBLY OF PROP-FAN BLADES

A. V. SRINIVASAN (United Technologies Research Center, East Hartford, CT), R. E. KIELB, and C. LAWRENCE (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 108, April 1986, p. 306-312. refs
(ASME PAPER 85-GT-134)

In contrast to conventional propellers, propfan blades are thin and highly swept-back, thereby giving rise to large bending and twisting deformations and complex vibratory characteristics. Aerodynamic performance depends on the extent of steady state deformation, and the aeroelastic response depends on the vibratory frequency and mode shape. Attention is presently given to the principal results of structural analyses for a five-bladed propfan assembly; these results are compared with test data. The results encompass both steady deformations and vibratory frequencies and mode shapes in a vacuum centrifugal environment. O.C.

**A86-32957*#** Pennsylvania State Univ., University Park.

### INFLUENCE OF FRICTION DAMPERS ON TORSIONAL BLADE FLUTTER

A. SINHA (Pennsylvania State University, University Park), J. H. GRIFFIN (Carnegie-Mellon University, Pittsburgh, PA), and R. E. KIELB (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 108, April 1986, p. 313-318. refs
(ASME PAPER 85-GT-170)

This paper deals with the stabilizing effects of dry friction on torsional blade flutter. A lumped parameter model with single degree of freedom per blade has been used to represent the rotor stage. The well-known cascade theories for incompressible and supersonic flows have been used to determine the allowable increase in fluid velocity relative to the blade. It has been found that the effectiveness of friction dampers in controlling flutter can be substantial. Author

**A86-33266**

### DYNAMIC ANALYSIS OF STRUCTURES WITH FLEXIBLE ROTORS

M. GERADIN and N. KILL (Liege, Universite, Belgium) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 477-485. refs

The paper describes the analytical tools developed for the structural dynamic analysis of machines with rotating parts such as aircraft engines. The finite element analysis is used for discretization, and the rotating parts are described using a three-dimensional formalism which includes in the kinetic energy expression the gyroscopic effects induced by the local changes of angular velocity produced by the deformation. The implementation of the formalism is specialized to the modelling of flexible rotors made of shafts and disks as it is typical for modern aircraft engines. The effectiveness of the component mode synthesis method to reduce the size of the system of equations is demonstrated in the specific case of systems made of rotating and fixed parts, governed by different sets of equations. Critical speed and stability analyses as well as unbalance response calculations are then performed by a sweeping procedure. As an illustration, the concepts presented are applied to the dynamic analysis of a high bypass ratio aircraft engine. Author

**N86-22577#** Department of the Air Force, Washington, D.C.

### IGNITER ELECTRODE LIFE CONTROL Patent Application

J. C. SCOTT, inventor (to Air Force) 7 Oct. 1985 11 p
(AD-D012007; US-PATENT-APPL-SN-784986) Avail: NTIS HC A02/MF A01 CSCL 11C

The prevention of electrode material erosion by undercutting in the outer electrode shell of igniter electrodes of jet engine ignition systems is prevented by the application of an electrical insulation coating. The coating is applied to the surface of the outer electrode shell which faces the ceramic insulation around the center electrode where erosion patterns are known to occur. The insulation material is selected from electrical insulation substances such as oxides of aluminum, tungsten, magnesium, beryllium or zirconium by choosing a non-porous electrical insulating substance with thermal expansion characteristics approximately equalling those of the outer electrode shell. Since a typical outer electrode shell is composed of 446 stainless steel, an optimum choice for the electrical insulation coating is $Al_2O_3$ deposited with a coating thickness of between 5 and 10 mils. Author (GRA)

**N86-22736#** Joint Publications Research Service, Arlington, Va.

### STATUE OF AIRCRAFT ENGINE RESEARCH AT NPU REVIEWED

*In its* China Report: Science and Technology (JPRS-CST-86-004) p 40-45 28 Jan. 1986 refs Transl. into ENGLISH from Guoji Hangkong (Beijing, China), no. 10, Oct. 1985 p 4-6
Avail: NTIS HC A06/MF A01

The aircraft engine research work at Northwest Polytechnic University is intended to satisfy the needs of national defense and the aviation industry on the one hand, and to serve China's economic development on the other. The efforts were devoted to the following two areas: (1) exploring advanced design methods of high-performance propulsion systems, studying new topics in jet propulsion technology, developing our experimental capabilities and striving to improve measurement techniques; and (2) providing wide range of technical services to the mechanical, power, energy exploration and local industries in the areas of product design, application of new technologies, and development of new energy sources. Modern jet propulsion technology is closely tied to state-of-the-art scientific development and the development of electronic computers; it has evolved from a single technical discipline to the combined study of many different disciplines. The areas of research are discussed briefly. Author

**N86-23599#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**THROTTLE DEPENDENT FORCES: A PRIMER Final Report, Aug. 1982 - Nov. 1984**
D. L. BOWERS Nov. 1985 129 p
(AD-A162939; AFWAL-TR-85-3055) Avail: NTIS HC A07/MF A01 CSCL 21E

An introduction to the broad area of throttle dependent forces for airbreathing aircraft, primarily subsonic to supersonic capable is provided. Basic concepts and examples are presented for subsonic, supersonic and transonic inlet and nozzle applications. Experimental and analytical determination of throttle-dependent forces is discussed, including approaches and potential problems. A final reference section of basic definitions is included for completeness. GRA

**N86-23601#** Pratt and Whitney Aircraft, West Palm Beach, Fla. Engineering Div.
**FRACTURE MECHANICS OF MULTIPLE CRACK INITIATIONS. AN APPLICATION FOR FRACTURE MECHANICS ANALYSIS OF GAS TURBINE ENGINE DISKS Interim Report, Feb. 1981 - Jun. 1983**
B. A. COWLES, A. B. THAKKER, and G. E. KING Oct. 1985 44 p
(Contract F33615-80-C-5160; DARPA ORDER 3993)
(AD-A162998; PW/ED/FR-18778; AFWAL-TR-85-4110) Avail: NTIS HC A03/MF A01 CSCL 21E

The purpose of this task was to investigate the current life prediction methodology for multiple crack growth in gas turbine engine components. To this end, experimental and analytical efforts were carried out. Current prediction methods for very small cracks (as small as 0.005 x 0.010 inches) were modified to address the larger interacting cracks produced by the controlled preflaw methods used in this program. The authors conclude that: (1) The modified crack growth life prediction technique currently in use resulted in acceptable but conservative predictions in all cases. Variability in the predictions was also acceptable and was similar to variability in predicted versus actual results for singular crack cases. (2) The multiple-degree-of-freedom approach also produced acceptable life predictions and, in fact, demonstrated reduced variability in predicted versus actual results. It was, however, more complicated to use and did not result in a consistent conservative bias in the life predictions. (3) Based on this study, the modified crack growth life prediction technique currently in use is considered adequate for Retirement-for-Cause applications. The multiple-degree-of-freedom approach offers potential improvements for future use. GRA

# 08

# AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-30499*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**DIRECTIONAL HANDLING QUALITIES REQUIREMENTS FOR NAP-OF-THE-EARTH TASKS**
C. C. BIVENS (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, Jan. 1986, p. 37-42. refs

A piloted simulator experiment designed to investigate directional axis handling qualities requirements for low-speed and hover tasks conducted by a scout/attack helicopter is described. Included were the directional characteristics of various candidate light helicopter family (LHX) configurations. The test also focused on conventional single main/tail rotor configurations where the first-order effects that contribute to the loss of tail rotor control experienced by the OH-58 series aircraft were modeled. Two types of yaw stability and control augmentation systems were implemented: washed-out yaw rate feedback and shaped control input, and a yaw rate command, heading-hold system. The results of the experiment indicate that rotorcraft configurations with high directional gust sensitivity require more yaw damping to maintain satisfactory handling qualities during nap-of-the-earth (NOE) flying tasks. It was also determined that both yaw damping and control response are critical handling qualities parameters in performing the air-to-air target acquisition and tracking task. The lack of substantial yaw damping and larger values of gust sensitivity increased the possibility of loss of directional control at low airspeeds for the tail rotor configurations. Author

**A86-30925**
**THE AEROMECHANICS OF AIRCRAFT: FLIGHT DYNAMICS (2ND REVISED AND ENLARGED EDITION) [AEROMEKHANIKA SAMOLETA: DINAMIKA POLETA /2ND REVISED AND ENLARGED EDITION/]**
A. F. BOCHKAREV, ED. and V. V. ADREEVSKII, ED. Moscow, Izdatel'stvo Mashinostroenie, 1985, 360 p. In Russian. No individual items are abstracted in this volume. refs

A handbook for aviation students on the physics of flight is presented. Among the specific topics discussed are: the equations of motion governing aircraft in flight; aircraft trajectory calculations; and methods for calculating nonlinear or quasi-linear flight regimes. The issues of aircraft stability and control are addressed, with emphasis given to: aerodynamic moment calculations; static lateral stability; and stability constraints in nonlinear flight regimes. Topics concerning the dynamics of perturbed flight regimes are also discussed, including: pitching moment perturbations; corkscrew motion; and lateral moment perturbations. I.H.

**A86-31125**
**FREQUENCY-DOMAIN APPLICATION OF GAUSS-NEWTON METHOD TO EXTRACT AIRCRAFT LONGITUDINAL PARAMETERS**
S. C. RAISINGHANI (Indian Institute of Technology, Kanpur, India) and A. K. GOEL (Defence Research and Development Laboratory, Hyderabad, India) Aeronautical Journal (ISSN 0001-9240), vol. 90, Jan. 1986, p. 27-34. refs

The Gauss-Newton (GN) method is successfully applied in the frequency domain to extract aircraft longitudinal stability and control parameters from simulated flight data in calm air. Flight data at 128 points are generated and analyzed for six different types of elevator control inputs using the example of a business-jet aircraft. The initial values of the parameters are set arbitrarily at 0.5 to 1.5 times the true values to demonstrate the strength of the algorithm. Pseudorandom numbers are used to generate noisy data, and the present output error method is shown to yield good estimates even in the presence of high intensity measurement noise. It is demonstrated that the frequency-domain algorithm of the GN method is capable of giving better results as compared to the time-domain algorithm, and could achieve this in reduced computational time. R.R.

**A86-31660*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**INFLUENCE OF HIGH-ORDER DYNAMICS ON HELICOPTER FLIGHT-CONTROL SYSTEM BANDWIDTH**
R. T. N. CHEN (NASA, Ames Research Center, Moffett Field, CA) and W. S. HINDSON (Stanford University, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 190-197. Previously announced in STAR as N85-21174. refs

The increasing use of highly augmented digital flight-control systems in modern military helicopters prompted an examination of the influence of the influence of rotor dynamics and other high-order dynamics on control-system performance. A study was conducted at NASA Ames Research Center to correlate theoretical predictions of feedback gain limits in the roll axis with experimental test data obtained from a variable-stability research helicopter. Feedback gains, the break frequency of the presampling sensor filter, and the computational frame time of the flight computer were systematically varied. The results, which showed excellent theoretical and experimental correlation, indicate that the rotor-dynamics, sensor-filter, and digital-data processing delays can severely limit the usable values of the roll-rate and roll-attitude feedback gains. R.J.F.

**A86-31661#**

### AN INTERPRETATION OF AIRPLANE GENERAL MOTION AND CONTOL AS INVERSE PROBLEM

O. KATO and I. SUGIURA (Nagoya University, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 198-204. refs

A theoretical study for the inverse problem of the airplane general motion, that is, the problem of how an airplane should be controlled, when its flight maneuver is given, is described. An interpretation of this problem is made, and a general and practical method to solve the problem is developed. The distinctive features of this approach are to transform all the state variables of the airplane motion into the functions of the angle of attack alpha, sideslip angle beta and bank angle phi, and to pay special attention to the distinction between the flight-path angles and the flight attitude angles. By treating the triplet (alpha, beta, phi) as key variables it becomes easy to have insight into this complicated problem. This approach is applicable not only to conventional methods of motion and control but also to new and unusual methods through consideration of the degree of freedom of (alpha, beta, phi) for a given maneuver. A numerical calculation of an interesting flight maneuver is presented and discussed to illustrate the problem. Author

**A86-31662*#** Waterloo Univ. (Ontario).

### TRANSIENT MOTION OF A HYPERSONIC WEDGE, INCLUDING TIME HISTORY EFFECTS

W. H. HUI (Waterloo, University, Canada) and H. J. VAN ROESSEL Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 205-212. NSERC-supported research. Previously cited in issue 7, p. 857, Accession no. A85-19585. refs
(Contract NAGW-575)

**A86-32084*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

### REAL-TIME OPEN-LOOP FREQUENCY RESPONSE ANALYSIS OF FLIGHT TEST DATA

J. T. BOSWORTH (NASA, Flight Research Center, Edwards, CA) and J. C. WEST (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p. refs
(AIAA PAPER 86-9738)

A technique has been developed to compare the open-loop frequency response of a flight test aircraft real time with linear analysis predictions. The result is direct feedback to the flight control systems engineer on the validity of predictions and adds confidence for proceeding with envelope expansion. Further, gain and phase margins can be tracked for trends in a manner similar to the techniques used by structural dynamics engineers in tracking structural modal damping. Author

**A86-32114*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### FLIGHT INVESTIGATION OF A MULTIVARIABLE MODEL-FOLLOWING CONTROL SYSTEM FOR ROTORCRAFT

K. B. HILBERT, J. V. LEBACQZ (NASA, Ames Research Center, Moffett Field, CA), and W. S. HINDSON (Stanford University, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 14 p. refs
(AIAA PAPER 86-9779)

A high-bandwidth, multivariable, explicit model-following control system for advanced rotorcraft has been developed and evaluated on the NASA Ames CH-47B fly-by-wire helicopter. This control system has expanded the in-flight simulation capabilities of the CH-47B to support research efforts directed at the next generation of superaugmented helicopters. A detailed, analytical model of the augmented CH-47B has also been developed to support the flight tests. Analysis using this theoretical model was used to expose fundamental limitations caused by the basic vehicle characteristics and original control system implementation that had affected the performance of the model-following control system. Improvements were made to the nominal control system design to compensate for large time delays created by the higher-orderd dynamics of the aircraft and its control system. With these improvements, high bandwidth control and excellent model-following performance were achieved. Both analytical and flight-test results for the lateral axis are presented and compared. In addition, frequency-domain techniques are employed for documenting the system performance. Author

**A86-32136#**

### MANAGEMENT CONTROLS ON THE X-29 FLIGHT-CONTROL SYSTEM SOFTWARE DEVELOPMENT

N. J. FURIA (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9808)

Software management systems for the X-29 forward-swept-wing aircraft are described. Emphasis is given to a description of the Operational Flight Program (OFP) controlling all aerodynamic surfaces on the aircraft. Other important functions of the OFP include built-in-test (BIT), redundancy management, and fault reaction. The OFP hardware consists of a triple-redundant dual processor. An air-data function controls the input of air-data parameters (static and dynamic pressure) which are used to calculate a predetermined set of gains for control of Mach number, altitude, and angle of attack. Verification and validation tests were accomplished by several independent engineering teams and independent review teams have been organized to assess the test coverage. A functional block diagram of the OFP top-level hierarchy is provided. I.H.

**A86-32139*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### DEVELOPMENT OF SPIN RESISTANCE CRITERIA FOR LIGHT GENERAL AVIATION AIRPLANES

D. J. DICARLO, H. P. STOUGH, III, K. E. GLOVER, P. W. BROWN, and J. M. PATTON, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p. refs
(AIAA PAPER 86-9812)

A brief history of stall/spin technology for light general aviation airplanes is presented. Criteria needed to describe desirable characteristics of a spin-resistant airplane and means to evaluate airplanes for compliance with the criteria have been developed. Initial results from limited flight tests of an experimental high-wing airplane indicated that the basic configuration would not meet the spin resistance criteria. Further tests with the airplane modified to enhance its spin resistance are planned. Author

**A86-32146#**

### FIRST USE OF ADA IN FLIGHT-CRITICAL AVIONICS

M. D. BASS (McDonnell Aircraft Co., St. Louis, MO) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9822)

Ada higher-order computer software language was selected for application in an aircraft flight-critical avionic subsystem. The F-15 Control Augmentation System was modified from an analog system to a digital system, then programmed in Ada and tested throughout the aircraft flight envelope. This was the first use of Ada in flight hardware. The digital flight control system programmed in Ada performed nearly identical to the standard F-15 analog system. The suitability of Ada for use in military aircraft flight-critical avionics has thus been demonstrated. This paper discusses the test conduct and test results obtained, and describes the test aircraft modification. Author

**A86-32657**

**STABILITY OF A NONLINEAR STOCHASTIC SYSTEM UNDER PERIODIC EXCITATION [USTOICHIVOST' ODNOI NELINEINOI STOKHASTICHESKOI SISTEMY PRI EE PERIODICHESKOM VOZMUSHCHENII]**

I. D. CHERKASOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Jan.-Feb. 1986, p. 65-68. In Russian. refs

A stochastic Liapunov function is used to find stability conditions for a stochastic model of the vibrations of a helicopter rotor blade with allowance for horizontal turbulent fluctuations of the air velocity. The stochastic stability region of the system (in the weak sense) is established using the results of an earlier study (Khasminskii, 1969). The stability of the system in the strong sense and the asymptotic weak stability of the stochastic system in the absence of periodic excitation are also discussed. V.L.

**A86-33178**

**ADAPTIVE FLIGHT CONTROL OF UNSTABLE HELICOPTERS DURING TRANSITION**

H. OHTA, S. YOKOKURA (Nagoya University, Japan), P. N. NIKIFORUK, and M. M. GUPTA (Saskatchewan, University, Saskatoon, Canada) IN: A bridge between control science and technology. Volume 2 . Oxford and New York, Pergamon Press, 1985, p. 1045-1050. Research supported by the Ministry of Education of Japan. refs

(Contract NSERC-A-5625; NSERC-A-1080)

The design of an adaptive control system for a helicopter during transitional flight conditions is discussed. A mathematical model of the controlled plant and a model reference adaptive system (MRAS) is described. The identification speed and control performance of the system are examined. Simulation studies that reveal the problems associated with the identification and control techniques are presented. An adaptive algorithm based on MRAS and developed using the discrete Kalman filter is proposed. Stability derivative data are employed to predict the time-varying characteristics of the parameters. Examples displaying the applicability of the adaptive flight control system are provided. I.F.

**A86-33180**

**A DISCRETE ADAPTIVE OBSERVER FOR A MULTI-OUTPUT AIRCRAFT CONTROL SYSTEM**

N. HORI, P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada), and K. KANAI (Defense Academy, Yokosuka, Japan) IN: A bridge between control science and technology. Volume 2 . Oxford and New York, Pergamon Press, 1985, p. 1057-1062. refs

A state feedback system is described for controlling the longitudinal motion of an unknown aircraft using an adaptive observer applicable to multi-output systems. This observer is a simple extension of the single-output case and does not require the decomposition of the system. The design of the overall control system is, therefore, as simple as that for single-variable systems. For purposes of clarification, a singular control problem is investigated, but not the closed loop stability. Author

**A86-33246**

**FLUTTER CALCULATION BY A NEW PROGRAM**

V. J. E. STARK (SAAB-Scania AB, Linkoping, Sweden) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 276-285. Research supported by the Forsvaret Materielverk anad SAAB-Scania AB. refs

A new flutter and response program based on general equations of motion is described. The equations are solved by Laplace transformation and by mainly reducing the inversion integral to a sum of the residues at the poles at the zeros of the determinant. The resulting nonlinear eigenvalue problem, i.e. the problem of finding the zeros, is solved by using the Newton-Raphson formula combined with efficient numerical methods for calculation of the determinant and the principle of the argument for finding initial approximations. The program permits choice of different kinds of analytic functions in the linear approximation that is employed for approximating the aerodynamic transfer functions. Equations representing control laws of a flutter suppression system can be included. Author

**A86-33248*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DEVELOPMENT OF A FLUTTER SUPPRESSION CONTROL LAW BY USE OF LINEAR QUADRATIC GAUSSIAN AND CONSTRAINED OPTIMIZATION DESIGN TECHNIQUES**

W. M. ADAMS, JR. and S. H. TIFFANY (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 297-308. refs

A control law is developed to suppress symmetric flutter for a mathematical model of an aeroelastic research vehicle. An implementable control law is attained by including modified LQG (Linear Quadratic Gaussian) design techniques, controller order reduction, and gain scheduling. An alternate (complementary) design approach is illustrated for one flight condition wherein nongradient-based constrained optimization techniques are applied to maximize controller robustness. Author

**A86-33249**

**FINITE STATE MODELLING OF AEROELASTIC SYSTEMS FOR ACTIVE CONTROL APPLICATIONS - A GENERAL THEORY**

R. VEPA (Queen Mary College, London, England) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 309-319. refs

In this paper various techniques of modelling aeroelastic systems for active control applications are described. Three different approaches are available for this purpose and these are (1) the autonomous finite state approach (2) the time varying system approximation (3) the differential delay model. The differential delay model seems to be the simplest method of modelling aeroelastic systems. A design procedure for synthesizing optimal control laws for regulator design using the differential model is also briefly described. Author

**A86-33250**

**NLR EXPERIENCE IN THE APPLICATION OF ACTIVE FLUTTER SUPPRESSION AND GUST LOAD ALLEVIATION, APPLIED TO A WIND-TUNNEL MODEL**

P. A. VAN GELDER (National Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 320-329. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart and Nationaal Lucht- en Ruimtevaartlaboratorium. refs

In 1981, the National Aerospace Laboratory of the Netherlands started a research program to study the aeroelastic effects of active control systems. Control laws for flutter suppression and gust load alleviation systems were developed and tested using an aeroelastic wind-tunnel model in a subsonic wind tunnel with the capability to simulate discrete or random gusts. Flutter suppression up to the maximum wind tunnel speed of 1.4 V(f) was achieved, while the gust load alleviation system reduced the wing root bending moment by 25 percent at 0.9 V(f) for simulated gusts with a Dryden spectrum. Author

**A86-33251**
**THE DESIGN AND WIND TUNNEL DEMONSTRATION OF AN ACTIVE CONTROL SYSTEM FOR GUST LOAD ALLEVIATION AND FLUTTER SUPPRESSION**
I. W. KAYNES, C. W. SKINGLE, and J. C. COPLEY (Royal Aircraft Establishment, Farnborough, England) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 330-347.

**A86-33252**
**WINDTUNNEL TEST AND LABORATORY SIMULATION OF A LOAD ALLEVIATION SYSTEM FOR A MODERN TRANSPORT AIRCRAFT**
H. G. GIESSELER and G. BEUCK (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 356-361.

MBB-UT has within the scope of government sponsored programs worked out the technological fundamentals for the development of an aircraft with a Load Alleviation System. The design and realization procedure, a possible sensor and actuating concept, the way how the control law was derived and a possible operational concept are explained. The design and mechanization of a digital LAS-controller is explained. The performance of the control law and of the digital hardware using a wind tunnel model is shown. A planned and partly realized laboratory simulation is presented, which enables us to verify the design conditions of the LAS in real hardware environment and using an aeroelastic model of the aircraft. Author

**A86-33253**
**CONTROL LAW SYNTHESIS FOR GUST LOAD ALLEVIATION USING LINEAR QUADRATIC GAUSSIAN THEORY**
J. CHANG (Northwestern Polytechnical University, Xian, People's Republic of China) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 362-367.

Linear quadratic Gaussian synthesis is presently applied to the design of a flexible aircraft's multiloop gust load alleviation system in which the one-dimensional vertical gust is approximately modelled as the output of a linear system with a stationary white noise process as the input. A technique yielding a minimal number of augmented states is presented, and, for all the coefficient matrices, a matrix least-squares formula is established. System states are estimated by means of a Kalman-Bucy filter observer, and a cost function involving the performance index of ride quality and control surface deflections with a weighting matrix is used. The time domain formula for the rms value of the normal acceleration associated with the aircraft response to gusts is given. O.C.

**N86-22578** Tennessee Univ., Knoxville.
**INVESTIGATION OF THE DYNAMIC RESPONSE OF AIRCRAFT TO MICROBURST (JAWS) WIND SHEAR Ph.D. Thesis**
H. P. CHANG 1985 138 p
Avail: Univ. Microfilms Order No. DA8524117

A derivation of the governing equations of aircraft motion in variable wind field results in additional wind shear terms appearing in the force equations. Computer simulations of B727 type aircraft flying (landing and taking off) through the microburst (JAWS) wind shear data have been carried out and are in good agreement with those of the NASA/Ames B727 piloted simulator. The critical penetration heights through the center of the microburst are determined by computing the aircraft trajectory deviations from the intended flight path at the ILS Category 2 decision height window. It is found that the higher the magnitude of the wind gradient terms, the more influence they have on the aircraft performance, especially on sideslip angle, angle of attack, and rolling moment. The wind shear effects on three generic types of aircraft, a three-engine passenger airliner (PA), a twin-engines STOL (STOL), and an executive jet (EJ), are also investigated in this study. Dissert. Abstr.

**N86-22579*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A METHODOLOGY FOR AIRPLANE PARAMETER ESTIMATION AND CONFIDENCE INTERVAL DETERMINATION IN NONLINEAR ESTIMATION PROBLEMS Ph.D. Thesis - George Washington Univ., Apr. 1985**
P. C. MURPHY Apr. 1986 56 p refs Revised
(NASA-RP-1153; L-16009; NAS 1.61:1153) Avail: NTIS HC A04/MF A01 CSCL 01C

An algorithm for maximum likelihood (ML) estimation is developed with an efficient method for approximating the sensitivities. The ML algorithm relies on a new optimization method referred to as a modified Newton-Raphson with estimated sensitivities (MNRES). MNRES determines sensitivities by using slope information from local surface approximations of each output variable in parameter space. With the fitted surface, sensitivity information can be updated at each iteration with less computational effort than that required by either a finite-difference method or integration of the analytically determined sensitivity equations. MNRES eliminates the need to derive sensitivity equations for each new model, and thus provides flexibility to use model equations in any convenient format. A random search technique for determining the confidence limits of ML parameter estimates is applied to nonlinear estimation problems for airplanes. The confidence intervals obtained by the search are compared with Cramer-Rao (CR) bounds at the same confidence level. The degree of nonlinearity in the estimation problem is an important factor in the relationship between CR bounds and the error bounds determined by the search technique. Beale's measure of nonlinearity is developed in this study for airplane identification problems; it is used to empirically correct confidence levels and to predict the degree of agreement between CR bounds and search estimates. Author

**N86-22580*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**LOW-SPEED STABILITY AND CONTROL CHARACTERISTICS OF A TRANSPORT MODEL WITH AFT-FUSELAGE-MOUNTED ADVANCED TURBOPROPS**
Z. T. APPLIN and P. L. COE, JR. Apr. 1986 67 p refs
(NASA-TP-2535; L-16004; NAS 1.60:2535) Avail: NTIS HC A04/MF A01 CSCL 01C

A limited experimental investigation was conducted in the Langley 4- by 7-Meter Tunnel to explore the effects of aft-fuselage-mounted advanced turboprop installations on the low-speed stability and control characteristics of a representative transport aircraft in a landing configuration. In general, the experimental results indicate that the longitudinal and lateral-directional stability characteristics for the aft-fuselage-mounted single-rotation tractor and counter-rotation pusher propeller configurations tested during this investigation are acceptable aerodynamically. For the single-rotation tractor configuration, the propeller-induced aerodynamics are significantly influenced by the interaction of the propeller slipstream with the pylon and nacelle. The stability characteristics for the counter-rotation pusher configuration are strongly influenced by propeller normal forces. The longitudinal and directional control effectiveness, engine-out characteristics, and ground effects are also presented. In addition, a tabulated presentation of all aerodynamic data presented in this report is included as an appendix. Author

**N86-22581*#** Information and Control Systems, Inc., Hampton, Va.

**EXTENSIONS TO PIFCGT: MULTIRATE OUTPUT FEEDBACK AND OPTIMAL DISTURBANCE SUPPRESSION**

J. R. BROUSSARD Mar. 1986 121 p refs
(Contract NAS1-17493)
(NASA-CR-3968; NAS 1.26:3968; IR-684105) Avail: NTIS HC A06/MF A01 CSCL 01C

New control synthesis procedures for digital flight control systems were developed. The theoretical developments are the solution to the problem of optimal disturbance suppression in the presence of windshear. Control synthesis is accomplished using a linear quadratic cost function, the command generator tracker for trajectory following and the proportional-integral-filter control structure for practical implementation. Extensions are made to the optimal output feedback algorithm for computing feedback gains so that the multirate and optimal disturbance control designs are computed and compared for the advanced transport operating system (ATOPS). The performance of the designs is demonstrated by closed-loop poles, frequency domain multiinput sigma and eigenvalue plots and detailed nonlinear 6-DOF aircraft simulations in the terminal area in the presence of windshear. E.A.K.

**N86-22582*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**THE MEASUREMENT OF AIRCRAFT PERFORMANCE AND STABILITY AND CONTROL AFTER FLIGHT THROUGH NATURAL ICING CONDITIONS**

R. J. RANAUDO, K. L. MIKKELSEN, R. C. MCKNIGHT, R. F. IDE, A. L. REEHORST, J. L. JORDAN, W. C. SCHINSTOCK, and S. J. PLATZ 1986 46 p refs Presented at the 3rd Flight Testing Conference, Las Vegas, Nev., 2-4 Apr. 1986; cosponsored by AIAA, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE Prepared in cooperation with Kohlman Systems Research, Inc., Lawrence, Kansas
(NASA-TM-87265; E-2962; NAS 1.15:87265; AIAA-86-9758)
Avail: NTIS HC A03/MF A01 CSCL 01C

The effects of airframe icing on the performance and stability and control of a twin-engine commuter-class aircraft were measured by the NASA Lewis Research Center. This work consisted of clear air tests with artificial ice shapes attached to the horizontal tail, and natural icing flight tests in measured icing clouds. The clear air tests employed static longitudinal flight test methods to determine degradation in stability margins for four simulated ice shapes. The natural icing flight tests employed a data acquisition system, which was provided under contract to NASA by Kohlman Systems Research Incorporated. This system used a performance modeling method and modified maximum likelihood estimation (MMLE) technique to determine aircraft performance degradation and stability and control. Flight test results with artificial ice shapes showed that longitudinal, stick-fixed, static margins are reduced on the order of 5 percent with flaps up. Natural icing tests with the KSR system corroborated these results and showed degradation in the elevator control derivatives on the order of 8 to 16 percent depending on wing flap configuration. Performance analyses showed the individual contributions of major airframe components to the overall degration in lift and drag. Author

**N86-22583#** European Space Agency, Paris (France).

**ROBUSTNESS OF DISCRETE-TIME DYNAMICAL SYSTEMS: APPLICATION TO THE MULTIVARIABLE DIGITAL CONTROL OF COMBAT AIRCRAFT**

Y. JOANNIC Oct. 1985 266 p refs Transl. into ENGLISH of "La Robustesse des Systemes Dynamiques a Temps Discret: Application au Pilotage Numerique Multivariable des Avions d'Armes" Rept. ONERA-NT-1984-2 ONERA, Paris, France, 1984 Original language document was announced as N85-19986
(ESA-TT-906; ONERA-NT-1984-2) Avail: NTIS HC A12/MF A01

A method for computing optimal feedback laws, capable of maintaining accurate tracking despite constantly acting disturbances was developed and applied to flight control of combat aircraft. A formalism reduces robustness to preservation of stability in a properly augmented system. This leads to theoretical results which quantify the generalized structural robustness of a recurrent nonlinear multiple-loop system. After extending the Lyapunov criterion to systems having dynamical feedback, the classical concepts of stability margin and of gain and phase margins are generalized to the multivariable discrete case. Analytical expressions which enable margins to be evaluated when dynamical or nonlinear perturbations affect the feedback channels are given. By applying theorems on external stability to a recurrent system, the tolerable additive perturbations which do not destabilize the controlled system are quantified. Author (ESA)

**N86-23603*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DEVELOPMENT EXPERIENCE WITH A SIMPLE EXPERT SYSTEM DEMONSTRATOR FOR PILOT EMERGENCY PROCEDURES**

M. VANNORMAN and D. A. MACKALL Feb. 1986 17 p refs
(NASA-TM-85919; H-1272; NAS 1.15:85919) Avail: NTIS HC A02/MF A01 CSCL 01C

Expert system techniques, a major application area of artificial intelligence (AI), are examined in the development of pilot associate to handle aircraft emergency procedures. The term pilot associate is used to describe research involving expert systems that can assist the pilot in the cockpit. The development of expert systems for the electrical system and flight control system emergency procedures are discussed. A simple, high-level expert system provides the means to choose which knowledge domain is needed. The expert systems were developed on a low-cost, FORTH-based package, using a personal computer. Author

**N86-23604*#** Tennessee Univ., Tullahoma. Atmospheric Science Div.

**ANALYSIS OF DATA FROM NASA B-57B GUST GRADIENT PROGRAM Final Report**

W. FROST, M. C. LIN, H. P. CHANG, and E. RINGNES Sep. 1985 500 p refs
(Contract NAS8-36177; NAS8-35347)
(NASA-CR-178736; NAS 1.26:178736) Avail: NTIS HC A21/MF A01 CSCL 01C

Statistical analysis of the turbulence measured in flight 6 of the NASA B-57B over Denver, Colorado, from July 7 to July 23, 1982 included the calculations of average turbulence parameters, integral length scales, probability density functions, single point autocorrelation coefficients, two point autocorrelation coefficients, normalized autospectra, normalized two point autospectra, and two point cross sectra for gust velocities. The single point autocorrelation coefficients were compared with the theoretical model developed by von Karman. Theoretical analyses were developed which address the effects spanwise gust distributions, using two point spatial turbulence correlations. B.G.

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-29916#**

**ADVANCED CONCEPTS FLIGHT SIMULATION FACILITY**

S. L. CHAPPELL (Informatics General Corp., Moffett Field, CA) and G. A. SEXTON (Lockheed-Georgia Co., Marietta, GA) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 575-582.

Three identical Advanced Concepts Flight Simulation Facilities have been completed by NASA together with the Lockheed-Georgia Company. These simulation facilities, based on projected air travel needs and technology available for flight by 1995, have three components: (1) the Advanced Concepts Flight Station (ACFS); (2) an integrated air traffic control simulation; and (3) experimenter/observer stations. The ACFS is based on a hypothetical wide-body composite airframe propelled by two turbo-fan engines that has a range of 2500 miles and carries 200 passengers. The optimized airframe design produces a negative static margin and relies upon a three-axis stability augmentation system for manual aircraft control. Features incorporated into its components include: voice-operated cathode ray tube displays of flight systems information, clearance print-outs, cockpit traffic displays, current datebases containing navigational charts, fuel-efficient autopilot control from takeoff to touchdown, and an outside visual scene withy variable weather conditions. It has been shown that this cockpit is a versatile test-bed for studying displays, controls, procedures, and crew management in a full-mission context. K.K.

**A86-29917#**
**THE DEVELOPMENT OF AN ADVANCED HELICOPTER RESEARCH SIMULATOR**
F. J. MALKIN (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 585-589.

A helicopter flight simulator is developed which will be used as a research tool through which advanced controls and displays, and varying levels of automation will be evaluated in terms of their impact on human performance. The part task and total crew station/system environment simulation investigations include display formats and side-arm flight control considerations. The crew station accepts a variety of display devices, and control input schemes including key pads, a thumb-controlled joy stick for maneuvering the display cursor, and a speech recognition device. A low-cost computer-generated image system video-projects images onto a large screen. The experimenter's console will be used in the development, monitoring, and result analysis of experiments. Applications include the development of the LHX. R.R.

**A86-31012#**
**THE EXTENSION OF THE MADEIRA AIRPORT RUNWAY - A UNIQUE TASK [LA PROLONGACION DE LA PISTA DE VUELO DE MADEIRA - UNA OBRA SINGULAR]**
M. GARCIA CRUZADO (INTECSA; Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Jan. 1986, p. 32-34. In Spanish.

The civil engineering undertaking which the extension of two runways (by respectively 50 and 150 m) at Madeira airport represented in 1982, in order to accommodate such aircraft as DC-9s and B727s, is presently discussed with attention to the accommodation of difficult terrain. The structures built are of steel-reinforced concrete and in the case of one of the two extensions employed a row of columns that extended to the sea shore. O.C.

**A86-31124**
**THE 'MINITUFT' SURFACE FLOW VISUALISATION METHOD - EXPERIENCE OF USE IN THE RAE 5M PRESSURISED LOW-SPEED WIND TUNNEL**
D. G. DOBNEY, P. HANSON, and S. P. FIDDES (Royal Aircraft Establishment, Aerodynamics Dept., Farnborough, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Jan. 1986, p. 10-17.

The development and use of a 'minituft' surface flow visualization technique in the RAE 5m Pressurized Low-Speed Wind Tunnel is described. The method, due to Crowder, uses very fine nylon monofilaments to show surface flow direction. These tufts are made visible by coating them in a fluorescent dye and then illuminating them with a powerful ultra-violet light source. Because of their small size, a large number of tufts may be used without interfering with the flow to a great extent. However, it is shown that if accurate force measurements are required, then it is advisable to test the model in the absence of tufts. Author

**A86-31847*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THE NATIONAL TRANSONIC FACILITY**
H. K. HOLMES (NASA, Langley Research Center, Hampton, VA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, Feb. 1986, p. 1-7.

The National Transonic Facility, NTF, is a high Reynolds Number facility where the increase in Reynolds Number is obtained by operating at high pressures and low temperatures. Liquid nitrogen is allowed to vaporize, making gaseous nitrogen the test medium with temperatures extending down to approximately 100 degrees Kelvin. These factors have created unique, new challenges to those developing sensors and instrumentation. Pressure vessels, thermal enclosures or elaborate temperature compensations schemes, are needed for environmental protection and special materials are needed for sensors and model fabrication. The need for a new measurement, model deformation, was also created. An extensive program to develop the unique sensors and instrumentation was initiated. The data acquisition system and systems to measure aerodynamic forces and pressures, model attitude, and model deformation, are discussed. Author

**A86-32089#**
**MISSION CONTROL FEATURES AT YUMA PROVING GROUND**
R. MAI (U.S. Army, Analysis and Computation Branch, Yuma Proving Ground, AZ) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9745)

An inventory is presented of the real time data collection, processing, and display capabilities that are available to test customers at the U.S. Army's Yuma Proving Ground (USAYPG) in Arizona, with emphasis on the information available for display in using USAYPG mission control rooms during typical aircraft navigation and aircraft armament testing. Information is categorized according to origin as video data, field instrumentation data, and telemetry data. USAYPG is unique among test ranges in its total integration of telemetry and field instrumentation data in a single, real time processing computer. O.C.

**A86-32090#**
**THE MBB FLIGHT TEST CENTRE AND ITS FACILITIES**
K.-H. BURGER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 11 p.
(AIAA PAPER 86-9746)

This paper gives a summarizing introduction of the Flight Test Center of the Messerschmitt-Boelkow-Blohm Company (MBB), as it presents itself today. Starting with flight test organization, management and worksharing, the test facilities and test ranges are described. Emphasis is laid on flight monitoring, computer systems for analyses, and development of analysis software which may be used on-line to some extent. In this field MBB is preparing itself especially for the flight test program of the future fighter aircraft of the German Air Force. Finally a review about conducted flight test programs is given. Author

**A86-32091#**
**TRACKING RADARS AT FLIGHT TEST RANGES**
A. E. HOFFMANN-HEYDEN (RCA Missile Test Project, Patrick AFB, FL) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p.
(AIAA PAPER 86-9747)

The paper reviews the evolution of operational tracking radars up to their current status, and their role in Test Range Instrumentation for measurements on flying targets. The major milestones of technical developments and the impact of digital computers are addressed and exemplified. Emphasis is placed on the use of computers to achieve enhanced radar performance and a host of auxiliary refinements and capabilities through software programs. Among these, sophistication and automation of calibration techniques increased the accuracy capabilities of high-quality radar systems for the benefit and consistency of metric data acquisition in the Test Range environment. Author

**A86-32092#**
**AIR FORCE FLIGHT TEST CENTER RANGE OVERVIEW**
L. SMITH (USAF, Flight Test Center, Edwards AFB, CA) and E. RAMIREZ (USAF, Hill AFB, UT) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 6 p.
(AIAA PAPER 86-9748)

Over 75 percent of all Air Force Systems Command air vehicle testing is conducted at the Air Force Flight Test Center. In direct support of this activity are two instrumented ranges (the Air Force Flight Test Center and the Utah Test and Training Range) and a data acquisition and transmission corridor between them which stretches from Edwards AFB in southern California to Hill AFB in Utah. These terminal areas can function as separate entities or as a single range for extended flights. Data can be acquired in real-time in each area and by remote sites located along the microwave link between them. This paper addresses the Mission, Management, Resources and Future Plans for these ranges. Author

**A86-32105#**
**COMPUTER GRAPHICS SUPPORT OF A NEW ERA IN FLIGHT TEST GROUND STATIONS**
P. T. VESELY (Grumman Corp., Grumman Data Systems, Alverton, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PPER 86-9769)

The use of computer graphics in the flight testing of aircraft is examined. The performance and display characteristics of the Megatek 7255 and the Tektronix 4115B graphic engines are evaluated and compared. The Megatek 8255 is a higher performance terminal; however, the Tektronix has superior resolution and visual display area. The components and functions of the failure status monitor which utilizes color graphics to display detected failures are described. The new display and control system uses the Tektronix to produce high quality displays; the real-time graphics provided by the system are discussed. The operation of the mission display subsystem which provides time, space, and positioning information is studied. A layout of a data analysis station is presented. I.F.

**A86-32135#**
**INTEGRATION TEST FACILITY FOR P3 AIRCRAFT PURPOSE AND USES**
G. E. BURGESS (Lockheed-California Co., Burbank) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9807)

The P3 Integration Test Facility (ITF), geared towards both the integration of newly updated aircraft systems, and the functional testing and support of existing production equipment, is described. ITF Update III programs include an Acoustic Processor System for the P3C, and complete replacement of the acoustic sensor station equipment for active and passive sonar. Other ITF support functions include, satellite communications development for Satcom, program tape duplication, acoustic processing of real world data, and data link checkout of all production aircraft prior to delivery to the Navy. In addition to its avionics mock-up, the facility includes a development and demonstration facility incorporating an aircraft metal fuselage, consoles, and racks. Other ITF-type facilities are found in Canada and Japan. R.R.

**A86-32150#**
**RADAR CROSS SECTION TESTING**
H. C. GARRETSON, III (USAF, Radar Target Scatter Div., Holloman AFB, NM) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9828)

This paper discusses Radar Cross Section testing. The U.S. Air Force Radar Target Facility (RATSCAT) at Holloman Air Force Base, New Mexico is described. The two ranges at RATSCAT, RATSCAT Main and RAMS (RATSCAT Advanced Measurement System) are presented. Management and test philosophy at RATSCAT are presented with discussions of a unique surge-concept Operations and Maintenance contract and an evolving analysis capability. Author

**A86-33265**
**SIMULATION OF AIRCRAFT TAXI TESTING ON THE AGILE SHAKER TEST FACILITY**
R. FREYMANN (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) and W. P. JOHNSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 468-476. refs

The Aircraft Ground Induced Loads Excitation (AGILE) test facility is an array of three independent shakers which allow laboratory simulation of an aircraft taxiing on rough surfaces. It is shown how AGILE can be used in the dynamic qualification process and for verification of the mathematical structural model of an aircraft. Moreover, attention is focussed on experimental determination of the elastomechanical characteristics of aircraft landing gears and tires. Author

**N86-22737#** Joint Publications Research Service, Arlington, Va.
**SHANGHAI'S OUTDOOR AEROENGINE TEST FACILITY DETAILED**
*In its* China Report: Science and Technology (JPRS-CST-86-004) p 46-50 28 Jan. 1986 Transl. into ENGLISH from Hangkong Zhizao Gongcheng (Beijing, China), no. 7, 1 Jul. 1985 p 1-4
Avail: NTIS HC A06/MF A01

In November 1983, the outdoor test facility of the Shanghai Aircraft Engine Factory was officially certified by the technical certification conference sponsored by the National Defense Science and Engineering Committee, and was named the Shanghia Outdoor Test Facility for Aircraft Engines. As China's first outdoor test facility, it was designed to perform the essential functions of new engine development, verification of engine performance, establishing momentum corrections for indoor test facilities, and studying the effect of weather and environmental conditions on engine performance. Author

**N86-23607#** New Mexico Univ., Albuquerque. Engineering Research Inst.
**RUNWAY RUBBER REMOVAL SPECIFICATION DEVELOPMENT: FIELD EVALUATION RESULTS AND DATA ANALYSIS Interim Report, Jul. 1984 - Jul. 1985**
R. A. GRAUL and L. R. LENKE Jul. 1985 108 p refs
(Contract F29601-84-C-0080)
(FAA/PM-85/32; ESL-TR-85-63; NMERI-WA5-6(5.04)) Avail: NTIS HC A06/MF A01

The phenomenon of runway touchdown zone rubber buildup which is a potentially hazardous problem is discussed. The use of pavement surface texture measurements is capable of determining pavement friction levels. The use of four economical texture measurement techniques and their relationship to friction levels as determined by the Mu-Meter are discussed. Good correlations are obtained by relating pavement surface texture measurements of friction. However, predictive errors preclude the use of these models in lieu of friction measurements for use in rubber removal guidelines. E.A.K.

**N86-23608#** National Aeronautical Establishment, Ottawa (Ontario).
**RECENT IMPROVEMENTS TO THE NAE 5 FT. X 5 FT. BLOWDOWN WIND TUNNEL**
L. H. OHMAN, D. BROWN, A. J. BOWKER, and F. A. ELLIS
Aug. 1985 41 p
(AD-A162034; NAE-AN-31; NRC-24882) Avail: NTIS HC A03/MF A01 CSCL 14B

Although the National Aeronautical Establishment (NAE) 5 ft x 5 ft Blowdown Wind Tunnel was conceived in the 1950's, with commissioning in 1962/63, it has stood the test of time very well and is still, in 1985, in heavy demand. Three main reasons for this situation are: (1) the basic wind tunnel design was fundamentally very sound; (2) the wind tunnel circuit and its auxiliary systems have frequently been improved and modernized so that it, even today, is a modern up-to-date facility; and (3) the high level of competence of the supporting staff. This report presents the major improvements made in recent years and the impact these have had on the performance of the facility. The improvements are: the rebuild of the settling chamber; the rebuild of the exhaust diffuser; the installation of active Mach number control for subsonic transonic operation; The incorporation of dual drive on the two-dimensional insert balance system; the suppression of edgetone noise; The incorporation of highly accurate digital pressure transducers; and the control and data processing system. Future plans for expanded use of the wind tunnel are outlined. GRA

**N86-23609#** General Accounting Office, Washington, D. C. Resources Community and Economic Development Div.
**INFORMATION ON AIRPORT AND AIRWAY TRUST FUND REVENUES AND OUTLAYS BY STATES AND LARGE AIRPORTS**
30 Sep. 1985 38 p
(PB86-129665; GAO/RCED-85-153; B-219969) Avail: NTIS HC A03/MF A01 CSCL 01A

The Airport and Airway Trust Fund was established to ensure that taxes collected from commercial air passengers, private pilots, and other sources are expended only for the expansion, improvement, and maintenance of the nation's air transportation system. Estimates by states and large airports of taxes paid into the trust fund are presented. Selected trust fund moneys received in fiscal years 1979 to 1983 are estimated. GAO's ability to fully estimate trust fund revenues and outlays by states and large airports was restricted by data limitations that required GAO to make several broad assumptions. The GAO notes that by law, the primary purpose of the trust fund is to ensure the safe operation of this nation's airspace system, not to provide an even or equitable return of the tax revenues to airports and states. Author

## 10

## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-31348**
**AEROSPACE PLANES AND TRANS-ATMOSPHERIC VEHICLES - RECENT US STUDIES REVIVE DORMANT TECHNOLOGIES**
B. SWEETMAN Interavia (ISSN 0020-5168), vol. 41, March 1986, p. 305-308.

A technology-readiness and performance prospects evaluation is made for next-generation large aircraft capable of reaching and sustaining hypersonic (Mach 5 and above) speeds with air breathing powerplants as well as of leaving the earth's atmosphere for Space Shuttle-like operations employing nonairbreathing propulsion. Both DARPA and NASA are currently sponsoring research in the materials, configuration design, propulsion and fuel systems, and control and navigation methods, that are entailed by such vehicles. Attention is given to cryogenically fueled 'air turboramjet' engine technology, which encompasses turbojet (low speed), ramjet (high speed), and rocket (exoatmospheric) propulsion cycles. O.C.

**A86-32124#**
**REAL-TIME TELEMETERED INERTIAL GUIDANCE (TMIG) EVALUATION**
R. H. THOMPSON (USAF, Western Space and Missile Center, Vandenberg AFB, CA) and R. B. PICKETT (ITT, Vandenberg AFB, CA) AIAA, AHS, CASI, DGLR, TES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 4 p.
(AIAA PAPER 86-9795)

A primary safety problem of the National Test Ranges is related to the detection of, and response to, test vehicle failures which might pose an unacceptable risk to life and property. The inertial guidance (IG) system can accurately sense many types of potentially dangerous in-flight vehicle failures, and the data provided by it are routinely telemetered in real time. The evaluation of these data is discussed. The TMIG data is currently used as a secondary or backup source until late in the flight when the radar displays become noisy or unreliable. However, the reliance on radar data as the prime source for range safety displays leads to important questions in some scenarios. A discussion of these questions led to the formation of a special TMIG committee. The most important findings of the committee are summarized. G.R.

**A86-33299**
**STATISTICAL DYNAMICS AND CONTROL OPTIMIZATION OF FLIGHT VEHICLES [STATISTICHESKAIA DINAMIKA I OPTIMIZATSIIA UPRAVLENIIA LETATEL'NYKH APPARATOV]**
A. A. LEBEDEV, V. T. BOBRONNIKOV, M. N. KRASILSHCHIKOV, and V. V. MALYSHEV Moscow, Izdatel'stvo Mashinostroenie, 1985, 280 p. In Russian. refs

The application of the stochastic theory of control to the analysis and synthesis of control systems for flight vehicles is presented in a systematic manner. Topics discussed include methods of statistical description of random quantities, processes, and fields; methods of a priori statistical analysis of the controlled motion of flight vehicles; methods of estimating the states of flight vehicles; and programming of the optimal control of flight vehicles. Attention is then given to the synthesis of the optimal control of flight vehicles and optimal control under conditions of incomplete information. V.L.

## 11

## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-29972**
**FACTORS AFFECTING THE DESIGN OF MILITARY AIRCRAFT STRUCTURES IN CARBON FIBRE REINFORCED COMPOSITES**
B. W. ANDERSON (British Aerospace, PLC, Aircraft Group, Preston, England) IN: Advances in fracture research (Fracture 84). Volume 1 . Oxford and New York, Pergamon Press, 1986, p. 607-622.

Some of major factors and philosophies relating to the introduction of carbon fiber-reinforced epoxy matrices are reviewed. The basic rules governing the design of new laminate materials are discussed, including control tapering, blocking minimization, envelope tailoring, and reversible load buckling. Some of the structural limitations of laminates in design applications for military aircraft are also considered. These limitations include:

preprocessing and postprocessing variations from design standards; manufacturing and impact defects; notches due to loaded and unloaded holes; and environmental limitations with respect to temperature and moisture. Experimental data on the performance of carbon fiber reinforced composites in realistic military aircraft loading environments are given in an appendix. I.H.

**A86-30006**

### SPECTRUM FATIGUE CRACK GROWTH BEHAVIOR OF ALUMINUM ALLOYS

G. R. CHANANI, G. V. SCARICH, A. A. SHEINKER (Northrop Corp., Aircraft Div., Hawthorne, CA), and P. E. BRETZ (Aluminum Company of America, Alcoa Center, PA) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 1609-1621. Navy-sponsored research. refs

Constant amplitude and spectrum fatigue crack growth testing was performed on ten commercial 2000 and 7000 series aluminum alloy plate materials. The materials were selected to determine the effects of various alloying approaches including purity (fracture toughness) and temper (yield strength). Two different fighter aircraft spectra were used for testing; one represented the loading on a lower wing root and had predominantly tension loads, and the other represented a horizontal tail hinge and had high magnitude compression loads. Spectrum fatigue crack growth life did not correlate with yield strength and only correlated weakly with fracture toughness. In addition, tests were performed with a modification of one of the spectra to determine the effects of compressive loads. These tests showed that compressive loads in this complex, random spectrum significantly reduced the life. Nevertheless, the ranking of the materials was essentially the same for all three spectra. Author

**A86-30013**

### FATIGUE CRACK PROPAGATION FROM AN INCLINED CRACK UNDER COMBINED MODE LOADING

R. CHINADURAI, B. K. JOSHI (Civil Aviation Department, New Delhi, India), and R. K. PANDEY (Indian Institute of Technology, New Delhi, India) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 1703-1710. refs

The experiments conducted in the context of the present study involved the employment of aluminum alloy and steel which are utilized as structural materials in aircraft. Attention is given to details of fatigue testing and evaluation, the fatigue crack growth profile and the crack propagation direction, the determination of the crack growth rate, the fatigue crack growth rate as a function of various parameters, the effect of crack angle and stress level on the cyclic life, the crack propagation angle, and a comparison of experimental and theoretical crack growth rates. It is found that the average direction of fatigue crack growth is independent of crack size and stress amplitude. G.R.

**A86-30030**

### FATIGUE BEHAVIOUR OF ADVANCED ALUMINIUM ALLOY LUGS OF 7475-T761 WITH AND WITHOUT INITIAL CRACKS

A. BUCH and A. BERKOVITS (Technion - Israel Institute of Technology, Haifa) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 1983-1989. refs

7475 and 2024 Al-alloy lugs were tested under various test conditions. Spectrum and constant-amplitude tests showed that the total life of undamaged lugs of 7475-T761 aluminium alloy was not longer than that of conventional materials. This was probably because of the equally damaging effect of fretting in all materials compared. In the case of maneuver loading spectrum the crack propagation life of lugs with initial cracks was larger for the 7475-T761 lugs than for similar lugs made of 2024-T3. Author

**A86-30033**

### A WEAK BEAM TRANSMISSION ELECTRON MICROSCOPY STUDY OF A FATIGUE CRACK TIP IN A 2024 ALUMINUM ALLOY

K. RAJAN and R. L. HEWITT (National Aeronautical Establishment, Ottawa, Canada) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 2025-2032. refs

Weak-beam dark field transmission electron microscopy has been used to study the dislocation structure at a fatigue crack tip in 2024 aluminum. The region immediately ahead of the crack tip is characterized by a dislocation cell structure. Changes in the localized stress level at the crack tip are monitored by the measurement of the distribution of bowed out dislocation segments near cell walls. Author

**A86-31475**

### MATERIALS AND PROCESSES; PROCEEDINGS OF THE FIFTH TECHNOLOGY CONFERENCE, MONTREUX, SWITZERLAND, JUNE 12-14, 1984. VOLUMES 1&2

Conference sponsored by the Society for the Advancement of Material and Process Engineering. Geneva, Switzerland, Society for the Advancement of Material and Process Engineering, 1985. Vol. 1, 185 p.; vol. 2, 191 p. No individual items are abstracted in these volumes.

The present conference on advanced aerospace materials gives attention to high performance thermoplastic matrix composites and their manufacturing techniques, the filament winding of complex components, the mechanized manufacture of FRP components for aircraft secondary structures, a novel high strain-to-failure prepreg, the manufacture of accurate glass and carbon fiber preforms for resin injection, a helicopter composite tail unit, Al-Li alloys, the durability of Arall, the potential weight savings obtainable in future transport aircraft through the use of advanced materials, superplastically formed Ti and Al alloys for aerospace applications, and assembly bonding with room temperature-curing adhesives. Also discussed are novel composite systems for use in primary aircraft structures, accelerated moisture absorption in carbon-epoxy, the thermoanalytic characterization of matrix resins and composites, the definition of microstructures in hybrid reinforced plastics, ceramic components for automotive powerplants, Kevlar-reinforced automotive components, metallized textile fabrics and their applications, and the role of S-2 glass fibers in advanced composites. O.C.

**A86-33021**

### MULTIPURPOSE CORROSION INHIBITORS FOR AEROSPACE ALLOYS IN NAVAL ENVIRONMENTS

V. S. AGARWALA (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: New materials and new processes. Volume 3. 1985 . Cleveland, OH, JEC Press, Inc., 1985, p. 178-189. refs

Principles of corrosion and corrosion control applicable to crack tips were considered to evolve a new approach for the inhibition of cracking in high strength steels and aluminum alloys. Chemical systems were formulated with multifunctional properties such that a synergistically combined inhibitor system could modify, in situ the interfacial chemistry of the crack. Laboratory experiments were conducted to investigate the effects of such inhibitors on stress corrosion cracking and corrosion fatigue behavior of 4340 and 300M steels and 7075-T6 aluminum alloy. The inhibitor system 'DNBM' showed a significant effect in retarding crack growth rate in the alloys tested and also enhanced the threshold, K(1scc), for the aluminum alloy. The most promising application for the multifunctional concept has proven to be a chemical conversion coating for aluminum alloys. Author

**A86-33088**

**ACOUSTIC-BACKSCATTERING STUDIES OF TRANSVERSE CRACKS IN COMPOSITE THICK LAMINATES**

B. B. RAJU (Dayton, University, OH) Experimental Mechanics (ISSN 0014-4851), vol. 26, March 1986, p. 71-78. refs

(Contract F33615-83-5036)

The distribution of first-ply transverse cracks in graphite/epoxy 0.5-in. thick laminates was scanned by the acoustic-backscattering technique. The backscattering scans reveal a discrete number of characteristic dark bands in the case of specimens subjected to static loads or a low number of fatigue-load cycles. A dark band extending along the length of the specimen was obtained in specimens subjected to a high number of fatigue-load cycles. These dark bands reveal the three-dimensional distribution of transverse cracks situated in several adjacent planes. X-ray radiography shows the projection of the three-dimensional distribution of transverse cracks in the laminate plane and hence it may provide a low estimate of the distribution of transverse cracks in composite thick specimens. Author

**A86-33223**

**DISPERSION STRENGTHENED P/M ALUMINIUM ALLOYS**

I. B. MACCORMACK Metals and Materials (ISSN 0266-7185), vol. 2, March 1986, p. 131-134; 136, 137. refs

Attention is given to state-of-the-art techniques for the production of dispersoid phases in aluminum powder metallurgy base metal, with a view to the strength enhancement obtainable through the incorporation of a dispersion of fine intermetallic or nonmetallic particles. The merits of mechanical alloying, rapid solidification, and nonmetallic additions are assessed, with reference to both production parameters and prospective aerospace application requirements. The demand for superior mechanical properties at elevated temperatures in aerospace applications, however, cannot be fulfilled through dispersion strengthening of aluminum matrices with the carbides and oxides presently studied alone. O.C.

**A86-33323**

**THERMOPHYSICS OF DECOMPOSING MATERIALS [TEPLOFIZIKA RAZLAGAIUSHCHIKHSIA MATERIALOV]**

O. F. SHLENSKII, A. G. SHASHKOV, and L. N. AKSENOV Moscow, Energoatomizdat, 1985, 145 p. In Russian. refs

The principal characteristics of heat and mass transfer in various materials used in load-bearing and heat-insulating structural elements of advanced technical equipment, including flight vehicles, are examined. The procedures and equipment used for determining the thermophysical properties of decomposing and thermally stable materials in the temperature range 20-1000 C are described, and principal kinetic and thermal characteristics are presented for the most important classes of materials. Examples of thermal calculations for various structural elements are included. V.L.

**N86-22616#** Alcan International Ltd., London (England).

**THE DEVELOPMENT OF ALUMINUM-LITHIUM ALLOYS FOR AEROSPACE APPLICATIONS**

A. J. CORNISH, A. GRAY, W. S. MILLER, and M. A. REYNOLDS *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 195-201 Nov. 1985 refs

Avail: NTIS HC A13/MF A01

The development of aluminum-lithium based alloys is described by considering the reasons for the rapid growth of interest in the alloy type, the property targets sought, the compositions on which the major effort is concentrated, the properties achieved, and manufacturing. The objective is to achieve a 10% reduction in density relative to standard high strength alloys, together with a 10% increase in stiffness, while matching the strength and other service properties associated with the standard alloys. Two aluminum-lithium based alloys are under development to match the service properties of alloys in the 2000 and 7000 series. One alloy is used in different tempers, either to match the properties of the medium strength alloy 2014 T6 or to give a low density replacement for the damage tolerant alloy 2024 T3. The second has a higher strength and matches the properties of 7075 T6. Author (ESA)

**N86-22621#** Centre National d'Etudes Spatiales, Toulouse (France).

**NEW SPACE PAINTS**

J. C. GUILLAUMON *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 239-243 Nov. 1985 refs

Avail: NTIS HC A13/MF A01

White conductive paint with low solar absorptance (improvement of PCB-Z) (0.16 to 0.18); black conductive paint with low outgassing (improvement of PU1); white silicone paint with low solar absorptance (0.13); epoxy primer with low outgassing; and white conductive paint for launchers and aircraft were developed. Improvements under study are outlined. Author (ESA)

**N86-22642** Pittsburgh Univ., Pa.

**INTERACTIONS BETWEEN FLOW, HEAT AND MASS TRANSFER DURING FORMATION OF CARBON-FIBER REINFORCED EPOXY COMPOSITES Ph.D. Thesis**

Y. S. WANG 1985 174 p

Avail: Univ. Microfilms Order No. DA852482

Reinforced epoxy composites that contain long carbon fibers have shown strength and durability when used in aircraft secondary structures. The curing process of epoxy composites is complex. The polymerization reaction, heat and mass transfer, and flow have to be analyzed simultaneously. The interaction of cure kinetics, chemo-rheology, heat and mass transfer, and flow consolidation is concerned. The pregelation cure kinetics was described in terms of the overall reaction rate parameters and heat of polymerization using differential scanning calorimeter techniques. Viscosity measurements of the epoxy resin as a function of time at constant temperature were made at Lockheed Company and were combined with the kinetic data. The simultaneous heat and mass transfer was modeled mathematically. The density and thermophysical properties of the curing prepreg such as specific heat and thermal diffusivity were measured. Experiments were done with practical composite, simulated composite and also a macroscopic system to study the flow phenomena. Dissert. Abstr.

**N86-22648#** Construcciones Aeronauticas S.A., Madrid (Spain).

**ADVANCED COMPOSITE STRUCTURES IN COMMERCIAL TRANSPORT AIRCRAFT**

J. KOSHORST (Airbus Industrie) Nov. 1984 29 p

(AI/TE3-384/82-ISSUE-2) Avail: NTIS HC A03/MF A01

Design factors which govern the introduction of advanced composite structures on transport aircraft are reviewed. The efforts made in this field of technology must be balanced either through weight saving, manufacturing considerations, or increased structural performance. The A-310 aircraft is used to demonstrate how these objectives are met. Author (ESA)

**N86-22651#** Massachusetts Inst. of Tech., Cambridge. Dept. of Materials Science and Engineering.

**POTENTIAL OF COMPOSITE MATERIALS TO REPLACE CHROMIUM, COBALT AND MANGANESE IN CRITICAL APPLICATIONS**

J. CLARK 1985 160 p refs Sponsored by Office of Technology Assessment, Washington, D.C.

(PB86-123965) Avail: NTIS HC A08/MF A01 CSCL 11D

An analysis of the potential for substituting composite materials for critical materials in the jet engine, automotive and oil/gas equipment industries is given. It includes an assessment of the technical, economic and institutional factors contributing to direct and indirect substitution in these industries. GRA

**N86-22687*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**CERAMIC THERMAL BARRIER COATINGS FOR ELECTRIC UTILITY GAS TURBINE ENGINES**

R. A. MILLER 1986 15 p refs Presented at the 3rd Berkeley Conference on Corrosion, Erosion, and Wear of Materials, Berkeley, Calif., 29-31 Jan. 1986; sponsored by the National Association of Corrosion Engineers

(NASA-TM-87288; E-2994; NAS 1.15:87288) Avail: NTIS HC A02/MF A01 CSCL 11F

Research and development into thermal barrier coatings for electric utility gas turbine engines is reviewed critically. The type of coating systems developed for aircraft applications are found to be preferred for clear fuel electric utility applications. These coating systems consists of a layer of plasma sprayed zirconia-yttria ceramic over a layer of MCrAly bond coat. They are not recommended for use when molten salts are presented. Efforts to understand coating degradation in dirty environments and to develop corrosion resistant thermal barrier coatings are discussed. Author

**N86-22710#** Imperial Coll. of Science and Technology, London (England). Tribology Section.

**PHOSPHORUS ANTI-WEAR ADDITIVES IN HELICOPTER TRANSMISSIONS Final Report**

I. N. LACEY, H. A. SPIKES, and P. B. MACPHERSON Jun. 1985 85 p refs

(Contract MOD(RAE)-A12/1664)

(IC-TS015/85; BR96206) Avail: NTIS HC A05/MF A01

The action on helicopter transmissions of phosphonate ester antiwear additives was studied. It is shown that these additives form thick, polymeric films on rolling and rolling-sliding steel surfaces, and these films are able to greatly increase surface separation above that produced by normal elastohydrodynamic lubrication. Author (ESA)

**N86-22713*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.

**THERMAL BARRIER COATING LIFE PREDICTION MODEL DEVELOPMENT Annual Report**

K. D. SHEFFLER and J. T. DEMASI Nov. 1985 92 p refs

(Contract NAS3-23944)

(NASA-CR-175087; NAS 1.26:175087; AR-1) Avail: NTIS HC A05/MF A01 CSCL 11G

A methodology was established to predict thermal barrier coating life in an environment simulative of that experienced by gas turbine airfoils. Specifically, work is being conducted to determine failure modes of thermal barrier coatings in the aircraft engine environment. Analytical studies coupled with appropriate physical and mechanical property determinations are being employed to derive coating life prediction model(s) on the important failure mode(s). An initial review of experimental and flight service components indicates that the predominant mode of TBC failure involves thermomechanical spallation of the ceramic coating layer. This ceramic spallation involves the formation of a dominant crack in the ceramic coating parallel to and closely adjacent to the metal-ceramic interface. Initial results from a laboratory test program designed to study the influence of various driving forces such as temperature, thermal cycle frequency, environment, and coating thickness, on ceramic coating spalling life suggest that bond coat oxidation damage at the metal-ceramic interface contributes significantly to thermomechanical cracking in the ceramic layer. Low cycle rate furnace testing in air and in argon clearly shows a dramatic increase of spalling life in the non-oxidizing environments. Author

**N86-22724#** Suntech, Inc., Marcus Hook, Pa.

**TURBINE FUELS FROM TAR SANDS BITUMEN AND HEAVY OIL. PHASE 1: PRELIMINARY PROCESS ANALYSIS Interim Report, 8 Jul. 1983 - 9 Apr. 1984**

A. F. TALBOT, V. ELANCHENNY, A. MACRIS, and J. P. SCHWEDOCK 9 Apr. 1985 183 p

(Contract F33615-83-C-2352)

(AD-A161300; AFWAL-TR-85-2013) Avail: NTIS HC A09/MF A01 CSCL 21D

The strategic potential of domestic bitumens and heavy crude oils as substitutes for imported crude rests with their efficient conversion into aviation turbine fuels. In this Phase 1 study, preliminary analyses of several processing schemes have been performed. The comparison included both hydrogen addition and carbon rejection upgrading processes. Projected JP-4 yields, costs, and thermal efficiencies suggest further exploration of the hydrovisbreaking process. For Phase 2, laboratory scale demonstration of the recommended process is proposed. GRA

**N86-23663#** Royal Aircraft Establishment, Farnborough (England).

**FLEXURAL PROPERTIES OF CARBON FIBRE CLOTH/WOOD VENEER LAMINATES**

J. H. SEWELL Apr. 1985 23 p

(AD-A161921; RAE-TM-MAT-STR-1055; DRIC-BR-96647) Avail: NTIS HC A02/MF A01 CSCL 11E

Flexural tests have been made on epoxy or phenolic resin bonded hybrid laminates comprising carbon fiber cloth layers on wood veneer cores. Breaking loads and stiffnesses of many of the hybrids exceed those of all carbon fiber cloth laminates of the same weight per unit area of panel. This improvement in flexural properties can be accompanied by a significant decrease in materials costs owing to the replacement of expensive carbon fiber cloth by cheap wood veneers. Significant weight savings may be achieved if carbon fiber laminates are replaced by hybrid laminates having the same flexural breaking strengths or stiffnesses. GRA

**N86-23714#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).

**COMPARISON OF ALUMINUM ALLOYS CONCERNING STRENGTH AND DAMAGE TOLERANCE**

L. SCHWARMANN 21 Aug. 1985 21 p refs

(MBB-UT-111/85; REPT-TE-374/0723/85) Avail: NTIS HC A02/MF A01

The static strength, crack growth, and residual strength of high strength aluminum alloys used in aircraft engineering were investigated using approved material data. Alloys having high static strengths show worse crack growth and residual strength behavior compared with alloys having lower static strengths. The 2024-materials show the best crack growth behavior. The 7475-materials show the best residual strength behavior. Heat-treatment influences the crack growth and strength behavior significantly. Product form does not influence crack growth and strength behavior. The casting material A 357 T6 shows nearly the same crack growth behavior as the plate material 2024-T351, but shows worse strength behavior as compared with all other materials considered. Author (ESA)

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# ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-29870#**

### A PERIPHERAL INTEGRATED SYSTEM STATUS DISPLAY - FIGURAL GOODNESS OR PROXIMITY EFFECTS?

D. B. BERINGER (Wisconsin, University, Madison) IN: Symposium on Aviation Psychology, 3rd, Columbus, OH, April 22-25, 1985, Proceedings . Columbus, OH, Ohio State University, 1985, p. 183-187.

Certain problems arising in connection with peripheral or secondary displays are examined. Secondary display systems usually require additional visual scanning beyond the primary displays for system control. These secondary devices generally require the diversion of attention from primary displays used for flight control. The occurring lapses in primary task performance may contribute to a degradation in system performance. Such a degradation can be especially threatening in aviation systems used by commercial carriers. Attention is, therefore, given to alternate means of information display and their underlying desired qualities. 'Figural' displays are considered along with integrated displays, the present application used for experimentation, and the experimental examination of the display. The evaluated results suggest that the use of an integrated analog display allowing some shape or figural processing can be beneficial. G.R.

**A86-29954**

### UNIFIED APPROACH FOR MODELLING FATIGUE CRACK GROWTH AND SOME OBSERVATIONS ON BEHAVIOUR UNDER FLIGHT SIMULATION LOADING

K. N. RAJU and R. SUNDER (National Aeronautical Laboratory, Bangalore, India) IN: Advances in fracture research (Fracture 84). Volume 1 . Oxford and New York, Pergamon Press, 1986, p. 57-81. refs

The status of theories on fatigue crack growth under constant and variable amplitude loading is briefly reviewed. A unified model incorporating the concepts of energy balance, damage, and the phenomenon of crack closure is described in detail. The crack growth rate relation derived from the model is found to account for the effects of a number of parameters such as fracture toughness, stress ratio threshold thickness, and non-LEFM conditions. The damage concept used in the model makes it possible to determine the effects of environmental factors on crack growth rates, including rainfall counting to fatigue crack growth. Some problems encountered in extrapolating crack growth test data on the basis of simple laboratory specimens under flight simulation loading to predict crack growth in structures are examined. I.H.

**A86-29961**

### PROBABILISTIC FATIGUE AND FRACTURE DESIGN

A. O. PAYNE (Royal Melbourne Institute of Technology, Australia) IN: Advances in fracture research (Fracture 84). Volume 1 . Oxford and New York, Pergamon Press, 1986, p. 339-376. refs

A probabilistic approach to ultimate load failure and failure analysis under a wear-out process (due to fatigue or corrosion) is discussed. The approach is used to construct a theoretical model of structural behavior which makes it possible to evaluate the risks of ultimate load failure and failure in specific wear-out conditions. The probabilisitc procedure is illustrated by three examples including: (1) safety-by-inspection of a high strength steel aircraft structure with initial defects included; (2) design optimization for a semisubmersible drilling rig subject to corrosion; (3) and preliminary risk analysis for fatigue and fracture of a welded aluminum alloy road tanker. From a consideration of safety standards in various engineering design fields, the optimum probability of failure due to wear out processes should be less than 10 to the -4th p.a., and is insignificant at 10 to the -7th p.a. I.H.

**A86-30014**

### VARIATION OF EFFECTIVE STRESS RANGE RATIO UNDER SIMPLE VARIABLE AMPLITUDE LOADING

S. CHAND and S. B. L. GARG (M. N. R. Engineering College, Allahabad, India) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 1711-1718. refs

It is pointed out that in space vehicles and aircraft structures loading conditions in service are often complex. A number of crack propagation experiments involving different load patterns are reported. Attention is given to the experimental procedure, the development of U-models, an intermediate single Peak High Load Cycle (PHLC) in a Constant Amplitude Load (CAL) test, Hi-Lo load sequence tests and decrease in mean load sequence tests, an intermediate multi-PHLC applied in a CAL-test, and a comparison of Crack Growth Rate (CGR) model results with experimental results. G.R.

**A86-30019**

### FATIGUE OF STRUCTURAL MATERIALS AT HIGH-FREQUENCY CYCLE LOADING

V. A. KUZMENKO (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 1791-1798. refs

The operating conditions of many devices of modern technology can produce intensive periodic or random vibrations at high sonic or ultrasonic frequencies, taking into account gas turbine blades, and elements in other aircraft components. These vibrations can become the reason for fatigue fracture. On account of the importance of these phenomena, studies have been conducted of high-frequency cyclic loading (HFCL) fatigue and low-frequency cyclic loading (LFCL) fatigue. Attention is given to the cyclic loading frequency effect on the endurance limit of different materials, and the cyclic loading frequency effect on the fatigue crack growth rate. It is found that the difference between the fatigue characteristics due to different loading frequencies contributes to the increase in the safety factor and, consequently, to an enhancement in the component lifetime. G.R.

**A86-30027**

### SHORT CRACK DEVELOPMENT IN MECHANICAL STRUCTURES

J. NEMEC (Ceskoslovenska Akademie Ved, Ustav Teoreticke a Aplikovane Mechaniky, Prague, Czechoslovakia) and J. DREXLER (Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 1919-1925.

The physical background of short crack development is discussed, taking into account differences between the results provided by theoretical models and experimental findings. Differences between simplified models and real structures are found to be so pronounced that the applicability of both linear fracture mechanics and theoretical fracture mechanics is limited to developed macrocracks. Short crack systems in aircraft turbine disks are considered, giving attention to questions of basic importance in the solution of operational reliability problems, a statistical analysis concerning the problem of finding a representative description of the state of a structure, and a formula providing an acceptable lifetime estimation in the case of a short crack system for airworthiness requirements. G.R.

**A86-30034**

### FRACTOGRAPHIC STUDY OF FATIGUE CRACK KINETICS IN BODIES AND STRUCTURES

I. NEDBAL, J. SIEGL, and J. KUNZ (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia) IN: Advances in fracture research (Fracture 84). Volume 3 . Oxford and New York, Pergamon Press, 1986, p. 2033-2040. refs

Some quantitative fractographic analysis methods are outlined which can reveal the macroscopic characteristics of fatigue crack growth. Fractographic data related to crack length are transformed into a description of the fatigue process over time. This fractographic reconstruction of the kinetics of fatigue failure can yield information on failure processes in large-scale structures which are so far unavailable by other means. The results that can be obtained are demonstrated using two case studies of fatigue failure in aircraft structures. C.D.

**A86-30091**

### DURABILITY AND DAMAGE-TOLERANCE DESIGN AND ANALYSIS OF TITANIUM AIRFRAME STRUCTURES

J. B. CHANG (Rockwell International Corp., Los Angeles, CA) IN: Advances in fracture research (Fracture 84). Volume 5 . Oxford and New York, Pergamon Press, 1986, p. 3507-3516. refs

Durability and damage-tolerance requirements and analysis methodologies for Ti primary airframe structures of aircraft systems are described. Durability and damage-tolerance assessments are performed with an automated fatigue crack growth analysis computer code CRKGRO. The CRKGRO calculation of crack growth in cyclic-loaded structures, which is based on linear elastic fracture mechanics, is analyzed. The use of Gallagher's (1974) Willenborg retardation model and the Chang acceleration scheme of Chang et al. (1981) to develop a load interaction model is discussed. The Vroman linear approximation method of Chang et al. (1980) is the damage accumulation scheme for the computer program. The procedure for residual strength analysis is studied. The durability analysis methodology which evaluates the economic life of the structural components of an advanced aircraft is examined. An example of the durability and damage-tolerance analyses of the lower cover of a wing carry-through structure is provided. I.F.

**A86-30092**

### FATIGUE CRACK GROWTH IN PATCHED PLATES UNDER CONSTANT AMPLITUDE AND FLIGHT SIMULATION LOADINGS

R. CHANDRA and R. SUNDER (National Aeronautical Laboratory, Bangalore, India) IN: Advances in fracture research (Fracture 84). Volume 5 . Oxford and New York, Pergamon Press, 1986, p. 3523-3531. Research supported by the Aeronautics Research and Development Board. refs

Fatigue crack propagation was studied in aluminium alloy plates reinforced by adhesive bonding a unidirectional carbon fibre epoxy patch across the crack path. The tests were carried out under constant amplitude as well as flight simulation combat aircraft spectrum loading. Comparative tests were also conducted on unpatched plates. The composite patch considerably reduces crack growth rates. The improvement in resistance to fatigue crack growth is more pronounced under spectrum loading conditions. Author

**A86-30359**

### FAST MOTION SIMULATION

F.-X. DOITTAU, J. R. HURIET, and M. TISSOT (Societe Anonyme d'Etudes et Realisations Nucleaires, Limeil-Brevannes, France) IN: 1985 Summer Computer Simulation Conference, Chicago, IL, July 22-24, 1985, Proceedings . San Diego, CA, Society for Computer Simulation, 1985, p. 727-731.

The Sodern Visualization System (SVS) is a high luminous output video projector which modulates the light using Titus light-valves. These light-valves utilize a solid crystal dielectric target (deuterated potassium diacid phosphate) on which the electrical charge density is controlled by a scanned electron beam. The resulting voltage difference between the two crystal sides induces a proportional optical birefringence which is employed to modulate the polarization of light. The main characteristics of the SVS are discussed, and the influence of light-valve parameters and image source is examined. Attention is given to the light-valve parameters, image source characteristics, the image motion ratio, and the moving images displayed using the SVS. G.R.

**A86-30500**

### OPTIMAL SIZING OF COMPOSITE POWER TRANSMISSION SHAFTING

J. W. LIM (Maryland, University, College Park) and M. S. DARLOW (Rensselaer Polytechnic Institute, Troy, NY) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, Jan. 1986, p. 75-83. refs

(Contract DAAG29-82-K-0093)

The optimal design of composite drive shafting is developed with the goal of minimizing system weight. The study is illustrated with an application to a composite tail rotor drive shaft for advanced helicopters. It is also applicable to the design of composite synchronization drive shafts for helicopters and other composite shafts for aircraft, spacecraft and automobiles. The use and effectiveness of the optimal design procedure are demonstrated with an illustrative example. In the example, an optimized Graphite/Epoxy (G/E) T300/5208 tail rotor drive shaft with a single tube operating supercritically at 6000 RPM reduces system weight by as much as 63.1 percent compared to a conventional aluminum alloy tail rotor drive shaft system. Even constrained to subcritical operation, an optimized G/E (T300/5208) drive shaft with three tubes at 6000 RPM reduces system weight by as much as 38.1 percent. By comparison, simply replacing the five aluminum shaft sections with G/E (T300/5208) composite tubes operating at 5000 RPM results in a system weight reduction of, at best, only 15.3 percent. Author

**A86-30743#**

### CALCULATION OF RECIRCULATING FLOW BEHIND FLAME-HOLDERS

Q. ZENG, Y. SHENG, and Q. ZHOU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Oct. 1985, p. 495-497. In Chinese, with abstract in English. refs

Adoptability of standard K-epsilon turbulence model for numerical calculation of recirculating flow is discussed. Many computations of recirculating flows behind bluff-bodies used as flame-holders in afterburner of aeroengine have been completed. Blocking-off method to treat the incline walls of the flame-holder gives good results. In isothermal recirculating flows the flame-holder wall is assumed to be isolated. Therefore, it is possible to remove the inactive zone from the calculation domain in programming to save computer time. The computation for a V-shaped flame-holder exhibits an interesting phenomenon that the recirculation zone extends to the cavity of the flame-holder. Author

**A86-31123**

### A STRESS INTENSITY FACTOR SOLUTION DUE TO HOLES AHEAD OF GROWING CRACKS IN THIN SHEET MATERIAL

J. B. YOUNG and P. N. CAMPBELL (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Jan. 1986, p. 1-5. refs

The variation of the Crack Stress Intensity Factor (SIF), for two cracks growing from one hole only in an array of holes in an isotropic material under uni-axial tension has been studied. The effect of the fastener hole ahead of the growing crack was found to give an increase in the SIF only when the crack was within about one and a half diameters of the approached hole edge, compared with the level predicted by considering a single central hole in a plate. An equation suitable for inclusion in a crack growth program has been derived from the research results. Author

**A86-31187**

**NEW SYMMETRICAL CONDENSED NODE FOR THREE-DIMENSIONAL SOLUTION OF ELECTROMAGNETIC-WAVE PROBLEMS BY TLM**

P. B. JOHNS (Nottingham University, England) Electronics Letters (ISSN 0013-5194), vol. 22, Jan. 30, 1986, p. 162-164. refs

A new three-dimensional symmetrical condensed node for numerical simulation of electromagnetic waves by TLM has been developed. The advantages of the node are described, the scattering matrix is given and the use of the node in an electromagnetic scattering example is shown. Author

**A86-31253**

**AEROSPACE AND ELECTRONIC SYSTEMS - ADVANCED CONCEPTS AND PIONEERING PERSPECTIVES; PROCEEDINGS OF THE SIXTH SYMPOSIUM, DAYTON, OH, NOVEMBER 14, 15, 1984**

Symposium sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1984, 116 p. No individual items are abstracted in this volume.

Among the topics discussed are: the PRAM approach to technology transfer; all-electric aircraft development; and electronic enhancements for the combat aircraft cockpit. Consideration is also given to application of AI systems to military aircraft; ECM and ECCM technology; and the history of monolithic ICs. Developments in the USAF Avionics Integrity Program (AVIP) are reviewed, with emphasis given to: preventive measures for electrostatic discharges; corrosion prevention to increase avionics integrity; and criteria for stress screening temperature levels. I.H.

**A86-31258**

**SECTAM XII - PROCEEDINGS OF THE TWELFTH SOUTHEASTERN CONFERENCE ON THEORETICAL AND APPLIED MECHANICS, PINE MOUNTAIN, GA, MAY 10, 11, 1984. VOLUME 1**

Auburn, AL, Auburn University, 1984, 615 p. No individual items are abstracted in this volume.

Turbulence-related investigations are discussed, taking into account the formulation of three-dimensional boundary-layer equations for viscid/inviscid interacting flow, a theory for generating turbulent flow, numerical experiments in open-channel turbulence, the application of the K-E turbulence model to a boundary layer solution for flow about a spinning yawed projectile at Mach 3, and the simulation of late transition in plane channel flow. Other topics explored are related to wave propagation, nonlinear structural dynamics, computational methods, geomechanics, continuum mechanics, experimental methods, fluid mechanics, biofluid mechanics, vibrations of plates and shells, composite materials, fracture mechanics, interdisciplinary/applied problems, hydraulics, fluid-structure interaction, solid mechanics, and the theory of shells. Attention is given to an analysis of a superplastically formed and diffusion bonded sandwich panel, the composite repair of a cracked aluminum alloy aircraft structure, and the determination of turbomachinery blade characteristics for vibration analysis. G.R.

**A86-31259**

**SECTAM XII - PROCEEDINGS OF THE TWELFTH SOUTHEASTERN CONFERENCE ON THEORETICAL AND APPLIED MECHANICS, PINE MOUNTAIN, GA, MAY 10, 11, 1984. VOLUME 2**

Auburn, AL, Auburn University, 1984, 586 p. No individual items are abstracted in this volume.

Subjects in the area of fluid mechanics are discussed, taking into account heat-up flows of a contained fluid, an analytical solution for natural convection in a vertical oriented porous annulus, the Weissenberg effect generated by a torsionally oscillating rod in a layered medium, a system analysis for a model of bluff body base flow, steady solutions of the shallow water equations, and the subsonic near-wake of an axisymmetric body with a slanted base. Computational methods are considered along with structural vibrations, structural stability, experimental methods, coastal hydrodynamics, dynamical systems, large space structural systems, the hydraulics of sediment transport, localization of deformation, wave propagation, vibrations of plates and shells, composite materials, and design studies. Attention is given to damage tolerance studies in operational aircraft, design verification testing of advanced prototype structures, continuous filament wound grid stiffened composite structures for aircraft fuselages, and Navier-Stokes solutions for two-dimensional subsonic base flow. G.R.

**A86-31356**

**SUPERSONIC INTERFACE INSTABILITIES OF ACCELERATED SURFACES AND JETS**

C. L. GARDNER (New York University, NY) Physics of Fluids (ISSN 0031-9171), vol. 29, March 1986, p. 690-695. refs
(Contract DE-AC02-76ER-03077)

The compressible Rayleigh-Taylor instability of a supersonic accelerated contact discontinuity between two gases is studied by numerically solving the two-dimensional Euler equations. The computed solutions exhibit a complicated set of nonlinear waves comprised of spike and bubble bow shocks, terminal shocks within the spike and bubble, Kelvin-Helmholtz rollup of the spike tip, and contact surface waves. The spike appears to attain a finite growth of aspect ratio approximately equal to 2. The propagation of a supersonic slab jet is also studied numerically, in order to compare and contrast the jet wave structure with that of the supersonic accelerated surface. Author

**A86-31374**

**PLASTIC TORSION OF HOLLOW ELEMENTS OF AIRCRAFT [PLASTICHESKOE KRUCHENIE POLYKH ELEMENTOV LETATEL'NYKH APPARATOV]**

IU. P. KATAEV Moscow, Izdatel'stvo Mashinostroenie, 1985, 128 p. In Russian. refs

Engineering methods are presented for calculating the plastic torsion parameters of hollow elements of aerodynamic cross-sectional shape whose thickness varies along the contour length. Methods are also presented for calculating the stress-strain state of hollow elements of aircraft under loading and unloading for varying twist angle and force parameters. The discussion also covers automatic control of the torsion of such aircraft components as the spars of helicopter rotor blades and problems related to dynamic plastic torsion. V.L.

**A86-31412**

**A GENERAL CRITERION IN DESIGN [K VOPROSU OB OBSHCHEM KRITERII V PROEKTIROVANII]**

IU. A. KOZLOV, V. N. NOSIK, and A. F. PROTSENKO Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 51, 1984, p. 31-35. In Russian.

A criterial approach to the design process and to the qualitative evaluation of the designed components is examined with particular reference to aircraft design applications. It is shown that the criterial concept of the development of a design idea and its evaluation at all stages of the development enable a quantitative expression of elements of an interrelated system of criteria and a transition to the general assessment of the quality of the product at each stage. V.L.

**A86-31417**

**A STUDY OF AN ITERATION METHOD FOR THE ANALYSIS OF PLATES WITH PARALLEL STIFFNESS RIBS AS SYSTEMS OF SUPERELEMENTS [ISSLEDOVANIE ITERATSIONNOGO SPOSOBA RASCHETA PLASTIN S PARALLEL'NYMI REBRAMI ZHESTKOSTI KAK SISTEM SUPERELEMENTOV]**

IU. P. PETROV and V. K. ZAITSEV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 51, 1984, p. 59-74. In Russian.

**A86-31420**

**A MATHEMATICAL MODEL FOR STRUCTURES CONSISTING OF ELASTIC SHELL SECTIONS CONNECTED BY OPEN GIRDERS [MATHEMATICHESKAIA MODEL' KONSTRUKTSII, SOSTOIASHCHIKH IZ UPRUGIKH OTSEKOV OBOLOCHEK, SOEDINENNYKH OTKRYTYMI FERMAMI]**

N. M. KHARUN Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 51, 1984, p. 83-88. In Russian.

A method is proposed for developing a mathematical model describing the stress-strain state of structures consisting of thin-walled discretely reinforced shell sections connected by open girders. The model proposed here is based on the theory of composite systems and is particularly relevant to the design of load-bearing aircraft structures. V.L.

**A86-31773**

**FREE VIBRATION CHARACTERISTICS OF PERIODICALLY STIFFENED PANELS WITH DAMPED STRINGERS**

B. V. R. GUPTA (Andhra University, Waltair, India), S. NARAYANAN, and N. GANESAN (Indian Institute of Technology, Madras, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 105, March 8, 1986, p. 351-356.

It is shown that constrained damping treatment on the flanges of the stiffener of a periodic sheet-stringer panel provides less overall damping than unconstrained damping treatment on the flanges. The resonant frequencies are observed to increase. This type of treatment is also shown to give maximum damping for frequencies corresponding to the stringer torsion mode and minimum damping for the stringer bending mode in the plane of symmetry. In all cases, these trends are the same as those found for unconstrained damping treatment by Narayanan, Gupta, and Ganesan (1984). C.D.

**A86-31921**

**RADIO COMMUNICATION BETWEEN MANOEUVRING PLATFORMS**

G. W. MILLWARD (British Aerospace, PLC, Dynamics Group, Bristol, England) IN: International Conference on Antennas and Propagation (ICAP 85), 4th, Coventry, England, April 16-19, 1985, Proceedings . London and New York, Institution of Electrical Engineers, 1985, p. 343-347. refs

A method for deriving the probability distribution of the link margin is proposed. The effects of attitude on antenna gain and cross-polarization loss are examined. The relative distribution of energy between the specular and diffuse reflections of the multipath signals is determined by the roughness of the terrain, grazing angle, and transmission frequency. The relation between the absorption coefficient and height, water vapor content, the earth's curvature, and refraction is discussed. Platform height, maneuver, and velocity, which influence multipath propagation and antenna gain, are studied. An example in which the probability distribution of link margin is calculated for a short range ground-to-air system for a single aircraft is provided. I.F.

**A86-32314**

**ADVANCES IN DISPLAY TECHNOLOGY V; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JANUARY 24, 25, 1985**

E. SCHLAM, ED. (U.S. Army, Electronic Technology and Devices Laboratory, Fort Monmouth, NJ) Meeting sponsored by SPIE - The International Society for Optical Engineering. Bellingham, WA, SPIE - The International Society for Optical Engineering (SPIE Proceedings. Volume 526), 1985, 124 p. For individual items see A86-32315 to A86-32323.

(SPIE-526)

Display human factors, and various advanced display systems, including CRT and projection display systems, electroluminescent displays, and passive displays, are discussed. Papers are presented on the selection of the best visual system, the effects of adaptation and display luminance on CRT symbol recognition time, and minimum color differences required to recognize small objects on a color CRT. Consideration is given to such display systems as a 160 megapixels per second 2000 line display, a full color liquid crystal light valve projector, and a thin film electroluminescent display optimized for cockpit application. Papers on passive displays include those on amorphous silicon thin film transistor-driven liquid crystal displays, a display based on switchable zero-order diffraction grating valves, and a liquid crystal display system for mass audience viewing. I.S.

**A86-32318**

**160 MEGAPIXELS PER SECOND 2000 LINE DISPLAY**

J. A. MAYS (Electronic Image Systems, Inc., Xenia, OH) IN: Advances in display technology V; Proceedings of the Meeting, Los Angeles, CA, January 24, 25, 1985 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 43-50.

A program to develop a 2048-by-2048 pixel display is described. Key technical limits are identified, and a R&D program to advance the state-of-the-art by constructing a monochrome and color feasibility model display is discussed. The paper will concentrate on the CRTs, the 160-megapixels/sec video circuitry, and the deflection systems developed for the two feasibility model displays. Author

**A86-32320**

**DEVELOPMENT OF A RASTER/STROKE FULL-COLOR TV PROJECTOR FOR SIMULATION**

E. F. GENAW (Systems Research Laboratories, Inc., Dayton, OH) IN: Advances in display technology V; Proceedings of the Meeting, Los Angeles, CA, January 24, 25, 1985 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 59-66.

Advances in the simulation industry in Computer Image Generation (CIG) systems and the desire to go to very wide fields of view have created a need for advances in display technology. Hybrid CIG, combining sometimes conflicting raster and stroke (calligraphic) technologies, has furthered the need for advancement. This paper describes some of the challenges and solutions encountered in the production of a projector which fulfills these needs. Problems associated with off-axis projection, convergence, and dynamic spot size control are discussed. Author

**A86-32321**

**THIN FILM ELECTROLUMINESCENT (TFEL) DISPLAY OPTIMIZED FOR COCKPIT APPLICATIONS**

G. L. VICK, W. G. RUNYAN, R. F. COLTON, R. J. THORKILDSON, and J. S. TRCKA (Rockwell International Corp., Avionics Group, Cedar Rapids, IA) IN: Advances in display technology V; Proceedings of the Meeting, Los Angeles, CA, January 24, 25, 1985 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 71-74.

A thin film electroluminescent flat panel display, developed specifically for the aircraft cockpit is described. The film is a sandwich of Mn-doped ZnS between two layers of Y2O3. The features of the electrical drive, and an optical band pass filter are presented, and the problems of increasing light output from the display, reducing reflections, and enhancing contrast are discussed. Performance data on two sample displays are included. I.S.

**A86-32603**

**EFFECT OF RADAR FREQUENCY ON THE DETECTION OF SHAPED (LOW RCS) TARGETS**

D. MORAITIS and S. ALLAND (Hughes Aircraft Co., Culver City, CA) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 159-162. refs

The use of shaping to reduce the radar cross-section (RCS) of aircraft and missiles can result in the RCS varying significantly with radar operating frequency. This RCS sensitivity to frequency should be considered when selecting radar frequency and should be accounted for when evaluating radar performance. A detection range increase for shaped (low RCS) targets of a factor of two or greater can be realized for lower frequency radar (e.g., UHF-Band or L-Band) when compared to higher frequency radar (C-Band or X-Band). For low flying (sea skimming) targets, the RCS variation with frequency for shaped (low RCS) targets neutralizes the advantage that higher radar frequencies realize in multipath propagation resulting in approximately the same detection range across the radar bands from UHF to X-Band. Author

**A86-32605**

### DETECTABILITY OF LOW FLYING TARGETS IN REAL TERRAIN USING A DIFFRACTION MODEL

H. KUSCHEL (Forschungsgesellschaft fuer angewandte Naturwissenschaften, Forschungsinstitut fuer Hochfrequenzphysik, Wachtberg-Werthhoven, West Germany) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 169-174. refs

A method for the evaluation of transhorizon radar ranges in a short distance environment is described. The method is based on detailed terrain structure information using a digital terrain data base and on a multiple knife edge diffraction propagation model. From the results of a number of simulations in the different types of terrain being typical for Central Europe, mean transhorizon radar range curves are obtained, indicating the capability of radar systems to detect targets beyond the horizon. Varying parameters are the radar wavelength, the radar antenna height and the maximum free space radar range, where the latter depends on radiated power, antenna gain, radar cross section, and other parameters. Author

**A86-32614**

### DETECTION AND RECOGNITION OF HAZARDOUS WEATHER CONDITIONS BY PRIMARY SURVEILLANCE RADAR

W. KLEMBOWSKI (Przemyslowy Instytut Telekomunikacji, Warsaw, Poland) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 226-231. refs

The method of radar range prediction for the weather channel incorporated is PSR is presented. The recognition is based on the following assumptions: hazardous objects have height above the zero izotherm level and reflectivity greater than 40 dBZ. Results of weather clutter detection in the weather channel of the L-band Polish PSR AVIA C are given. Author

**A86-32618**

### NEW CFAR-PROCESSOR BASED ON AN ORDERED STATISTIC

H. ROHLING (Telefunken AG, Ulm, West Germany) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 271-275. refs

In the present paper, a CFAR (constant false alarm rate) method is discussed using as the CFAR threshold one single value selected from the so-called ordered statistic. This procedure has some advantages over cell averaging CFAR, especially in cases where more than one target is present within the reference window on which estimation of the local clutter situation is based, or where this reference window is crossing clutter edges. Author

**A86-32642**

### COMPUTATIONALLY SIMPLE ADAPTIVE TRACKING FILTERS BASED ON WEIGHTED AVERAGES

E. THOMAS (Electronics and Radar Development Establishment, Bangalore, India) IN: International Radar Conference, Arlington, VA, May 6-9, 1985, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 416-423. refs

A new algorithm for state estimation, based on certain fading-memory weighted averages, is introduced. The state estimates are obtained through linear combinations of the weighted averages. In their basic general forms, the second-order and third-order Weighted Average Filters are equivalent to over-damped alpha-beta and alha-beta-gamma filters, respectively. Different linear combinations of the weighted averages give state estimates with different band-width characteristics simultaneously. This property leads to the decision-directed, multi-level, switching type adaptive filter described. In the swinging type adaptive filter described later, simple maneuver dependent modifications to the weighted averages make the filter continually self-adaptive to changing situations, with optimized parameters. The computational simplicity of this type is very attractive for tracking maneuvering targets in a real-time, multi-target environment. Author

**A86-32973#**

### NONLINEAR MULTIMODE RESPONSE OF CLAMPED RECTANGULAR PLATES TO ACOUSTIC LOADING

C. MEI (Old Dominion University, Norfolk, VA) and D. B. PAUL (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 2, p. 676-684) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 643-648. Previously cited in issue 12, p. 1745, Accession no. A83-29879. refs

(Contract AF-AFOSR-80-0107)

**A86-32975#**

### STEP RELAXATION METHOD FOR MODAL TEST IMPLEMENTED WITH FREQUENCY-DOMAIN PREPROCESSING

F. R. VIGNERON and Y. SOUCY (Department of Communications, Communications Research Centre, Ottawa, Canada) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 657-663. refs

A continuous longeron space mast having several low frequency, closely spaced modes is taken as an illustrative case demonstrating the 'step relaxation' method for modal testing, which encompasses the preprocessing of data in the frequency domain. Although excellent performance was obtainable in the 0-20 Hz range, the method was not successful for modes above 20 Hz. Attention is given to the construction of the measurement-based frequency-response function, and to parameter identification using a complex exponentials method. O.C.

**A86-32984*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### TURBULENT BOUNDARY-LAYER WALL PRESSURE FLUCTUATIONS DOWNSTREAM OF A TANDEM LEBU

G. B. BEELER (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 689-691. refs

An initial measurement of turbulent wall pressure fluctuations downstream of tandem large eddy breakup devices (LEBUs) indicates a significant reduction by comparison with the reference case of a flat plate; the average magnitude of the reduction is 12.5 percent. Peak reduction is at 7-8 kHz, and is of the order of the C(f) reduction due to the tandem LEBUs. These data indicate a secondary benefit derivable from LEBUs, in addition to their skin friction reduction effect. O.C.

**A86-33279**

### COMPARISON OF SOME TIME DOMAIN METHODS FOR STRUCTURAL SYSTEM IDENTIFICATION

J. E. COOPER and J. R. WRIGHT (Queen Mary College, London, England) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 595-604. refs

The modal parameters of a structural system may be identified from test data by a variety of frequency and time domain methods. In this paper three time domain methods, based on the difference equation model relating sampled response and excitation, are considered. The Least Squares, Instrumental Variables and Correlation Fit methods are described and applied to one and two mode simulated data in the presence of input or measurement noise with various noise-to-signal ratios. The results from a number of tests are compared statistically in order to examine the scatter on damping results and whether they are biased. The Correlation Fit method is seen to be the most suitable method for further development. Author

**A86-33292**
**CALCULATION OF STRUCTURAL ELEMENTS OF AIRCRAFT: SANDWICH PLATES AND SHELLS [RASCHETY ELEMENTOV AVIATSIONNYKH KONSTRUKTSII: TREKHSLOINYE PLASTINY I OBOLOCHKI]**
A. IA. ALEKSANDROV, ED., R. E. LAMPER, ED., and V. G. SUVERNEV Moscow, Izdatel'stvo Mashinostroenie, 1985, 208 p. In Russian. No individual items are abstracted in this volume.

The papers presented in this volume provide an overview of theoretical and experimental research in the field of sandwich plates and shells, with particular attention given to the stress-strain and stability analyses of sandwich structures under conditions of complex mechanical and thermal loading. Topics discussed include the transverse bending of sandwich beams, the stability of a cylindrical sandwich shell under compression, the effect of nonuniform heating on the stability of cylindrical sandwich shells under compression, and determination of the optimal parameters of sandwich plates and shallow shells with a honeycomb core under longitudinal compression and heating. Papers are also presented on the stability of a sandwich shell in shear and an iteration theory for the bending of essentially nonuniform plates. V.L.

**A86-33293**
**FREE-SURFACE FLOWS [TECHENIIA SO SVOBODNYMI POVERKHNOSTIAMI]**
G. V. LOGVINOVICH, V. N. BUIVOL, A. S. DUDKO, S. I. PUTILIN, and IU. R. SHERCHUK Kiev, Izdatel'stvo Naukova Dumka, 1985, 296 p. In Russian. refs

Results of recent theoretical and experimental research related to free-surface flows are reviewed. Topics discussed include potential flows with free boundaries, axisymmetric cavitation in an ideal fluid, flows in a longitudinal gravitational field, and a wing of low aspect ratio near a curved boundary. Attention is also given to some problems related to perturbations in cavitation flows, the effect of the cavitator orientation on the cavern shape, and liquid rotation in vortex funnels. V.L.

**A86-33419**
**IMPINGING JETS**
N. S. NOSSEIR (San Diego State University, CA) IN: Encyclopedia of fluid mechanics. Volume 2 . Houston, TX, Gulf Publishing Co., 1986, p. 349-366. refs
(Contract F49620-78-C-0060; N00014-84-K-0373)

The properties of an axisymmetric, subsonic jet impinging on an infinitely large flat plate are discussed. The mechanisms governing the behavior of the jet are explained based on experimental work. The turbulence characteristics of three modules of the jet are considered, namely the free jet, the stagnation flow, and the wall jet modules. Resonance phenomena at high speeds are examined, including feedback, phase lock, and collective interaction. It is shown that far-field noise is generated by two different mechanisms and propagates along two different paths. C.D.

**A86-33453#**
**SHAPE OPTIMIZATION OF AXISYMMETRIC STRUCTURES [OPTIMISATION DE FORME DES STRUCTURES AXISYMETRIQUES]**
C. LALLEMAND Lyon, Institut National des Sciences Appliquees, Docteur (3e cycle) Thesis, 1985, 154 p. In French. refs

Using the finite element method, a general algorithm for the shape optimization of axisymmetric structures subjected to nonsymmetric loading (Fourier series expansions) is presented. In this system, the tangential constraint is minimized, and the Lagrangian method is extended to the mathematical optimization of a function, subject to certain limitations. Several improvements are made on the gradient calculation. The system has application to the aerospace field, where mechanical reliability is crucial, and the method is demonstrated for the specific example of a helicopter gearbox. R.R.

**N86-22611#** Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France). Etablissement d'Aquitaine.
**HOLOGRAPHY: THE NONDESTRUCTIVE TESTING OF COMPOSITE STRUCTURES**
P. BARBIER and C. LEFLOCH *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 161-165 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

The principle of nondestructive testing by laser holographic interferometry, and the parts to be controled (parts of motor cases in composite materials) are discussed. The test facility, which involves a complex mechanical system, is described and the technical choices are justified. The economic aspects of the technique are outlined. Author (ESA)

**N86-22729#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
**LA RECHERCHE AEROSPATIALE, BIMONTHLY BULLETIN, NUMBER 1985-1, 224/JANUARY-FEBRUARY**
C. SEVESTRE, ed. ESA Oct. 1985 70 p refs Transl. by ONERA into ENGLISH of 'La Recherche Aerospatiale, Bulletin Bimestriel" (Paris, France), No. 1985-1, 224/Jan.-Feb. 1985
(ESA-TT-915) Avail: NTIS HC A04/MF A01; print copy in ENGLISH available at ONERA, Paris FF70; original report in FRENCH available at ONERA, Paris FF70

Aerodynamic methods for designing advanced high-speed propellers; a holography stand for high-definition image recording of transparent or opaque images; numerical analysis of singular stress fields at the free edge of layered composites; structure calculations in cyclic viscoplasticity; aircraft pseudo-noise and noise; and use of a radiance amplifier for visualizing seeded aerodynamic flows are discussed. Author (ESA)

**N86-22735#** Joint Publications Research Service, Arlington, Va.
**CHINA REPORT: SCIENCE AND TECHNOLOGY**
28 Jan. 1986 109 p refs Transl. into ENGLISH from various Chinese articles
(JPRS-CST-86-004) Avail: NTIS HC A06/MF A01

Various areas of scientific research in China is reported. The increased use of computers in economic development, information systems and meteorological work is described. Aircraft engine design and testing facilities are briefly discussed. The biological treatment of waste water is another area of discussion.

**N86-22914*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
**AN INTEGRATED DEVELOPMENT FACILITY FOR THE CALIBRATION OF LOW-ENERGY CHARGED PARTICLE FLIGHT INSTRUMENTATION Center Director's Discretionary Fund, Final Report**
A. P. BIDDLE and J. M. REYNOLDS Oct. 1985 24 p refs
(NASA-TM-86526; NAS 1.15:86526) Avail: NTIS HC A02/MF A01 CSCL 14B

A system was developed for the calibration and development of thermal ion instrumentation. The system provides an extended beam with usable current rates, approx. 1 pA/sq cm, at beam energies as low as 1 eV, with much higher values available with increasing energy. A tandem electrostatic and variable geometry magnetic mirror configuration within the ion source optimizes the use of the ionizing electrons. The system is integrated under microcomputer control to allow automatic control and monitoring of the beam energy and composition and the mass and angle-dependent response of the instrument under test. The system is pumped by a combination of carbon vane and cryogenic sorption roughing pumps and ion and liquid helium operating pumps. E.A.K.

**N86-22947** Department of the Air Force, Washington, D.C.
**FUEL PUMP VENT DRAIN SYSTEM Patent**
R. L. STANLEY and G. R. HENRY, inventors (to Air Force) 10 Sep. 1985 4 p Supersedes AD-D010870
(AD-D011993; US-PATENT-4,539,809; US-PATENT-APPL-SN-566445; US-PATENT-CLASS-60-39.094)
Avail: US Patent and Trademark Office CSCL 21E

A novel drain system for venting excess fuel from the fuel pump of a jet engine, and particularly the augmenter pump of a jet engine afterburner is described. It comprises a drain line connected at a first end to the vent valve of the fuel pump and at a second end to the main fuel supply line for the engine, for draining the excess fuel from the pump to the main fuel line; a check valve in the drain line near the second end thereof for restricting fuel flow through the drain line in a direction from the first end to the second end; and a vent line having a restriction therein defining an orifice of predetermined size connecting the drain line to an overboard dump port open to ambient. GRA

**N86-22985#** Rolls-Royce Ltd., Derby (England). Nondestructive Testing Div.
**LIMITATIONS OF MANUAL NDT SYSTEMS AND THE NO EYES CONCEPT**
R. G. TAYLOR 23 Jul. 1985 9 p
(PNR-90291) Avail: NTIS HC A02/MF A01

Defect tolerant design, particularly of aircraft components, and its links with nondestructive testing (NDT) are discussed. Engineering of the NDT technique, defect detection requirements, and human factors in the inspection cycle are considered. Author (ESA)

**N86-23012#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**AEROELASTIC RESEARCH ON WIND TURBINES Progress Report, 1 Jan. - 1 Jul. 1983 [NEGENDE VOORTGANGSRAPPORT. AERO-ELASTISCH ONDERZOEK AAN WINDTURBINES PERIODE 1 JANUARI TOT 1 JULI 1983]**
W. KUIK and W. P. KOPPENS Jun. 1983 5 p refs In DUTCH
(VTH-M-474; PR-9) Avail: NTIS HC A02/MF A01

Results and developments of aeroelastic investigations of tip vane wind turbines are presented. Aerodynamic (transfer) flow pieces were applied in the sharp angles between tip vanes and blades to reduce resistance caused by flow release. Analysis of the power curve shows a flow resistance reduction. Helicopter blades appear not to be optimal aerodynamically. Torsional stress measurements on the blade root show a higher flutter rpm, induced by a reduced aerodynamic load of the tip vane. Programs to predict ground resonances and whirl-flutter of a two bladed rotor on a pylon with symmetric stiffness were developed. The programs are part of a stability program which describes a flexible rotor on a flexible pylon. Author (ESA)

**N86-23013#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**MEP: A PROGRAM FOR CROSS SECTION MAGNITUDES OF A MULTICELL WING PROFILE [M.E.P. - EEN PROGRAMMA VOOR DOORSNEDEGROOTHEDEN VAN EEN MEERCELLIG VLEUGELPROFIEL]**
P. A. JOOSSE Oct. 1983 49 p refs In DUTCH
(VTH-M-487) Avail: NTIS HC A03/MF A01

Based on undisturbed thin walled multicell closed cross sections, an interactive program for the determination of the center of gravity, stress center, shear center, and torsional stiffness of wind turbine blades was developed. In the case of bending it is assumed that the cross sections stay plane, and stress is proportionate to elasticity (Hookes law). Based on the Saint Venant principle, the shear center was calculated using shear flow caused by cross forces. Wing profiles with a thickness/chord ratio 0.20 were assumed. Magnitudes of a three cell hexagon and a Kevlar NACA 23000 profile for tip vanes were calculated. Author (ESA)

**N86-23014#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**AEROELASTIC RESEARCH ON WIND TURBINES Progress Report, 1 Jul. 1983 - 1 Jan. 1984 [TIENDE VOORTGANGSRAPPORT. AERO-ELASTISCH ONDERZOEK AAN WINDTUBINES PERIODE 1 JULI 1983 TOT 1 JANUARI 1984]**
W. P. KOPPENS and W. KUIK Jan. 1984 7 p refs In DUTCH
(VTH-M-501; PR-10) Avail: NTIS HC A02/MF A01

Tip vane flow resistance was investigated, replacing blades by pipes. Experiments show resistances on the windward side, leading to malfunctioning of the turbine. A cross flow to which the helicopter wing profile used is sensitive was established. Aeroelastic wind tunnel model experiments were started. The importance of stall flutter at tip vane rotors is shown. From calculations it appears that the stability of the rotor can be increased by the application of flapping hinges in the blade root, giving the generator a rotation direction opposite to the rotor, and placing the rotor behind the pylon. Author (ESA)

**N86-23016#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**AEROELASTIC RESEARCH ON WIND TURBINES Progress Report, 1 Jan. - 1 Jul. 1984 [ELFDE VOORTGANGSRAPPORT. AERO-ELASTISCH ONDERZOEK AAN WINDTURBINES. PERIODE 1 JANUARI 1984 TOT 1 JULI 1984]**
W. P. KOPPENS and W. KUIK Jun. 1984 9 p refs In DUTCH
(VTH-M-517; PR-11) Avail: NTIS HC A02/MF A01

Results and developments of aeroelastic investigations of tip vane wind turbines are presented. The Liebeck (Kolibrie helicopter) wing profile was replaced by a NACA-23012 and a profile specially developed for tip vanes. The Liebeck profile is sensitive to disturbances (torsion) reducing the power coefficient. Flow resistance experiments show that the resistance is caused by viscous and induced resistances. Power curves of a one-blade rotor with and without tip vane were determined in a wind tunnel. The neglect in aeroelastic literature of the contribution of the dynamic profile curvature in case the angle of attack is used instead of the 3/4 chord point appears not permissible. Author (ESA)

**N86-23749*#** National Aeronautics and Space Administration, Washington, D.C.
**CHINESE SPACE AND AVIATION INDUSTRIES SCORE MAJOR BREAKTHROUGHS**
R. HU Apr. 1986 16 p Transl. into ENGLISH from Xiandai Junshi (Conmilit) (Hong Kong), v. 9, no. 11, 1 Jan. 1986 p 88-91 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-87973; NAS 1.15:87973) Avail: NTIS HC A02/MF A01 CSCL 13H

An overview of the current status of China's aviation and aerospace industries is presented, as well as planned future development and areas of importance for China's future space programs. The development of China's CZ-1, CZ-2 and CZ-3 rocket program is discussed, as well as China's satellite launch capabilities. China's first geostationary communications satellite STW-1 is also mentioned, and further development of the second and third communications satellites to be launched in 1987 are shown. Other developments include a seventh low Earth orbiting photographic reconnaissance satellite, plans for an image transmitting remote sensing satellite to be launched in 1988 to 1990, and other satellite developments. The Chinese-designed Y-10 transport aircraft is discussed, as well as the TU-16 bomber aircraft and the co-production agreement with McDonnell Douglas for the MD-82 passenger aircraft. Author

**N86-23752#** Southeastern Center for Electrical Engineering Education, Inc., St. Cloud, Fla.
**USAF/SCEEE (UNITED STATES AIR FORCE/SOUTHEASTERN CENTER FOR ELECTRICAL ENGINEERING EDUCATION) RESEARCH INITIATION PROGRAM RESEARCH REPORTS, VOLUME 2 Interim Report**
W. D. PEELE Mar. 1985 987 p
(Contract F49620-82-C-0035)
(AD-A161908; AFOSR-85-0905TR-VOL-2) Avail: NTIS HC A99/MF A03 CSCL 09C

A partial contents of this USAF/SCEEE report follows: A Study in the Mechanical Characterization of Advanced Composite Laminates; Modeling of Multi-Echelon and Multi-Indenture Items with Limited Repair and Transportation During War Time Emergencies; The Effect of Moderate to High Pitching Rates on the Aerodynamic Performance of a NACA 0015 Airfoil at a Reynolds No. of 100,000; Kinetic Energy Dependence of Ion Polar Molecule Collision Rate Constants by Trajectory Calculations; A Dynamic Resource Allocation Model; Electron Paramagnetic Resonance Study of Defects in III-V Semiconductor; and Effect of the Graph on Comprehension and Long-Term Recalls of the Text: Eye Movements in Reading. GRA

**N86-23773#** Joint Publications Research Service, Arlington, Va.
**JAPAN REPORT: SCIENCE AND TECHNOLOGY**
25 Mar. 1986 63 p Transl. into ENGLISH from various Japanese articles
(JPRS-JST-86-007) Avail: NTIS HC A04/MF A01

Progress in Japanese science and technology is reported. Topics discussed include: aerospace sciences, biotechnology, metallurgical industry, and new materials.

**N86-23783#** Royal Signals and Radar Establishment, Christchurch (England).
**AN INVESTIGATION OF SYNTHETIC APERTURE RADAR AUTOFOCUS**
I. P. FINLEY and J. W. WOOD Apr. 1985 44 p
(AD-A161912; RSRE-MEMO-3790; DRIC-BR-97350) Avail: NTIS HC A03/MF A01 CSCL 17I

SAR imagery is generated by matched filtering the raw azimuth signal history, assuming uniform straight line motion of the aircraft. Unknown aircraft motions alter the matched filter required for processing. Autofocussing involves determinating from the raw data the appropriate matched filter. In this document the principles of SAR and the requirement for an autofocus system are discussed. Three autofocus methods are investigated: measurement of the power spectrum, contrast maximization, and registration of multilook images. The power spectrum is shown to be unreliable as an autofocus aid. Results of the contract maximisation and registration methods are compared. GRA

**N86-23852*#** Vigyan Research Associates, Inc., Hampton, Va.
**DESIGN OF FUSELAGE SHAPES FOR NATURAL LAMINAR FLOW Final Report**
S. S. DODBELE, C. P. VANDAM, and P. M. H. W. VIJGEN (Kansas Univ., Lawrence, Kas.) Washington NASA Mar. 1986 41 p refs
(Contract NAS1-17926)
(NASA-CR-3970; NAS 1.26:3970) Avail: NTIS HC A03/MF A01 CSCL 20D

Recent technological advances in airplane construction techniques and materials allow for the production of aerodynamic surfaces without significant waviness and roughness, permitting long runs of natural laminar flow (NLF). The present research effort seeks to refine and validate computational design tools for use in the design of axisymmetric and nonaxisymmetric natural-laminar-flow bodies. The principal task of the investigation involves fuselage body shaping using a computational design procedure. Analytical methods were refined and exploratory calculations conducted to predict laminar boundary-layer on selected body shapes. Using a low-order surface-singularity aerodynamic analysis program, pressure distribution, boundary-layer development, transition location and drag coefficient have been obtained for a number of body shapes including a representative business-aircraft fuselage. Extensive runs of laminar flow were predicted in regions of favorable pressure gradient on smooth body surfaces. A computational design procedure was developed to obtain a body shape with minimum drag having large extent of NLF. Author

**N86-23873#** Michigan Univ., Ann Arbor. Dept. of Aerospace Engineering.
**THREE-DIMENSIONAL FLOW IN COMPRESSORS AND CHANNELS Final Report, 1 Mar. 1979 - 30 Sep. 1985**
T. C. ADAMSON, JR. and A. F. MESSITER Nov. 1985 23 p
(Contract N00014-79-C-0285)
(AD-A161858) Avail: NTIS HC A02/MF A01 CSCL 20D

This project was begun in 1979 as a study of three dimensional transonic flows through channels and between compressor blades. In the latter problem, the blades were to be lightly loaded. In 1981, a 3 year study with the broadened goal of studying flow problems in turbomachines was initiated. Specifically, the work was to include a continuation of that in progress on three-dimensional transonic flows through a lightly loaded compressor blade row, supersonic flow over a compression ramp with a turbulent boundary layer, and consideration of transonic flows over heavily loaded blades in a compressor, starting with a two-dimensional cascade and then going to a three-dimensional rotor if the calculations for the cascade was successful. The work in heavily loaded cascades was to build on the experience gained in the lightly loaded case. The work on the compression ramp has application at blade-shroud interfaces in transonic and supersonic flows. Asymptotic methods of analysis have been employed in all the problems to be described, with numerical methods of solution used as needed in some of the inner regions of the flow fields and to illustrate results for example problems. GRA

**N86-23874#** Naval Research Lab., Washington, D. C.
**ENERGY DISSIPATION OF LIQUIDS IN NUTATING SPHERICAL TANKS MEASURED BY A FORCED MOTION-SPIN TABLE Final Report, Jul. 1982 - Jul. 1984**
M. F. ZEDD and F. T. DODGE 30 Oct. 1985 29 p
(AD-A161864; NRL-8932) Avail: NTIS HC A03/MF A01 CSCL 21D

A specially constructed drive table is described that can spin and nutate scale-model propellant tanks. Results of typical tests are given in which the liquid resonant frequencies and liquid forces and moments are presented as a function of spin rate, nutation frequency, nutation cone angle, liquid filling level, and liquid viscosity. Also described is an empirical mechanical model composed of a pendulum, a rotor, and dashpots that simulate the liquid resonances (slosh and inertial waves) and the liquid forces and moments. The parameters of the model are determined from the propellant motions. Author (GRA)

**N86-23936*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
**EXTENDED PARAMETRIC REPRESENTATION OF COMPRESSOR FANS AND TURBINES. VOLUME 1: CMGEN USER'S MANUAL Final Report, Aug. 1982 - Oct. 1983**
G. L. CONVERSE and R. G. GIFFIN Mar. 1984 60 p refs 3 Vol.
(Contract NAS3-23055)
(NASA-CR-174645; NAS 1.26:174645; R84AEB378-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 13I

A modeling technique for fans, boosters, and compressors has been developed which will enable the user to obtain consistent and rapid off-design performance from design point input. The fans and compressors are assumed to be multi-stage machines incorporating front variable stators. The boosters are assumed to be fixed geometry machines. The modeling technique has been incorporated into time sharing program to facilitate its use. Because this report contains a description of the input output data, values of typical inputs, and examples cases, it is suitable as a user's manual. This report is the first of a three volume set describing

the parametric representation of compressors, fans, and turbines. The titles of the three volumes are as follows: (1) Volume 1 CMGEN USER's Manual (Parametric Compressor Generator); (2) Volume 2 PART USER's Manual (parametric Turbine); (3) Volume 3 MODFAN USER's Manual (Parametric Modulating Flow Fan).
Author

**N86-23937*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**EXTENDED PARAMETRIC REPRESENTATION OF COMPRESSOR FANS AND TURBINES VOLUME 2: PART USER'S MANUAL (PARAMETRIC TURBINE) Final Report, Aug. 1982 - Oct. 1983**

G. L. COVERSE Mar. 1984 61 p refs 3 Vol.
(Contract NAS3-23055)
(NASA-CR-174646; NAS 1.26:174646; R84AEB379-VOL-2)
Avail: NTIS HC A04/MF A01 CSCL 13I

A turbine modeling technique has been developed which will enable the user to obtain consistent and rapid off-design performance from design point input. This technique is applicable to both axial and radial flow turbine with flow sizes ranging from about one pound per second to several hundred pounds per second. The axial flow turbines may or may not include variable geometry in the first stage nozzle. A user-specified option will also permit the calculation of design point cooling flow levels and corresponding changes in efficiency for the axial flow turbines. The modeling technique has been incorporated into a time-sharing program in order to facilitate its use. Because this report contains a description of the input output data, values of typical inputs, and example cases, it is suitable as a user's manual. This report is the second of a three volume set. The titles of the three volumes are as follows: (1) Volume 1 CMGEN USER's Manual (Parametric Compressor Generator); (2) Volume 2 PART USER's Manual (Parametric Turbine); (3) Volume 3 MODFAN USER's Manual (Parametric Modulation Flow Fan).
Author

**N86-23938*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**EXTENDED PARAMETRIC REPRESENTATION OF COMPRESSOR FANS AND TURBINES. VOLUME 3: MODFAN USER'S MANUAL (PARAMETRIC MODULATING FLOW FAN) Final Report, Aug. 1982 - Oct. 1983**

G. L. CONVERSE Mar. 1984 50 p refs 3 Vol.
(Contract NAS3-23055)
(NASA-CR-174647; NAS 1.26:174647; R84AEB380-VOL-3)
Avail: NTIS HC A03/MF A01 CSCL 13I

A modeling technique for single stage flow modulating fans or centrifugal compressors has been developed which will enable the user to obtain consistent and rapid off-design performnce from design point input. The fan flow modulation may be obtained by either a VIGV (variable inlet guide vane) or a VPF (variable pitch rotor) option. Only the VIGV option is available for the centrifugal compressor. The modeling technique has been incorporated into a time-sharing program to facilitate its use. Because this report contains a description of the input output data, values of typical inputs, and examples cases, it is suitable as a user's manual. This report is the last of a three volume set describing the parametric representation of compressor fans, and turbines. The titles of the three volumes are as follows: (1) Volume 1 CMGEN USER's Manual (Parametric Compressor Generator); (2) Volume 2 PART USER's Manual (Parametric Turbine); (3) Volume 3 MODFAN USER's Manual (Parametric Modulating Flow Fan).
Author

**N86-23971** *Cincinnati Univ., Ohio.*

**INVESTIGATION OF MULTIPLE INPUT FREQUENCY RESPONSE FUNCTION ESTIMATION TECHNIQUES FOR EXPERIMENTAL MODAL ANALYSIS Ph.D. Thesis**

R. W. ROST 1985 237 p
Avail: Univ. Microfilms Order No. DA8526568

The accurate measurement of the frequency response function is vital to the estimation of the modal parameters of a system. The use of single input/output theory to formulate the equations for the frequency response function can be replaced by an equivalent theory involving multiple inputs. The results of this approach provide frequency response functions that are comparable to the single input/output case but with an increase in the consistency of modal frequency and damping values estimated from different frequency response functions. The concept of MAC, Modal Assurance Criterion, was expanded to include the possibility of multiple reference data. Numerous tests were conducted to evaluate and prove the techniques presented. The structures range from machine tools, airplanes, automobiles, electric generators, and encompass almost any large structure imaginable.
Dissert. Abstr.

# 13

# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-31225**

**AN ILL WIND**

J. W. WILSON (National Center for Atmospheric Research, Boulder, CO) Natural History (ISSN 0028-0712), vol. 95, March 1986, p. 48-51.

Downbursts which are produced when a rain shower or thunderstorm creates a current of rapidly downward moving air that spreads horizontally in a starburst pattern when it hits the ground are studied. Data from field experiments examining airflow in downbursts with Doppler radar and anemometers reveal that downbursts occur in varying sizes and strengths, and last for an average of 10-20 minutes. It is observed that microbursts are downbursts with diameter of 0.25-2.5 miles and they endanger aircraft. Variations in the intensity of the head wind and airflow over the wings affects the aircraft. The formation processes for cool air masses which cause the downdraft to reach the ground and produce microburst wind shear are examined. An experiment demonstrating the usefulness of wind shear warnings and the need to develop microburst real-time forecast and warning services are discussed.
I.F.

**A86-31955#**

**NOISE OF THE GENERAL AVIATION AIRPLANES INFLUENCE ON ENVIRONMENT OF THE AIRCLUB, AIRFIELDS AND ON CREWS**

S. GVOZDENOVIC, D. ZORIC (Beograd, Univerzitet, Belgrade, Yugoslavia), and M. TAUSANOVIC (Jugoslovenski Aerotransport, Belgrade, Yugoslavia) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 1. Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 307-310.

Noise measurements from general aviation at airport in Yugoslavia, both outside and inside the cockpit, are reported. Measurements were made at 1800 m and at 1000 m from the takeoff starting point, and the results are presented as a function of aircraft type. Noise levels are given for start of engine, taxiing, takeoff, climb, cruise, approach to landing, short final, and braking.
C.D.

**A86-31962#**

**WHAT SHOULD BE KNOWN ON THE ENVIRONMENTAL IMPACT ASSESSMENT FOR A PLANNING AIRPORT**

Z. MAEKAWA (Kobe University, Japan) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 871-874. refs

Attention is given to the development status of noise prediction methods applicable to commercial airport operations during the airport planning stage; such prognostications are notably complicated by meteorological effects. Projections are made on the basis of experimental long distance noise propagation data, theoretical calculations of the noise propagation effects of various meteorological conditions, and aircraft noise level measurements obtained to date for operations at Osaka International Airport. O.C.

**A86-31963#**

**A QUIET STOLPORT? CONVINCING THE PUBLIC**

J. G. CHARLES and W. STUBBS (Bickerdike Allen Partners, London, England) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 891-894.

Because of the need for efficient air travel between London and other centers, a plan was developed to introduce STOL aircraft services using quiet aircraft at a peninsular site wide enough and long enough for a 762 m STOL runway to be constructed. This paper discusses noise disturbances and the problem of convincing the public that an inland airport can be constructed within 20 min travel time of the city's center. The aircraft which would form the basis of any operation at the STOLport, the De Havilland Dash 7, was brought to the area to carry out a simulated approach and landing so that the public could actually experience the noise it made; noise measurements were made so that a data base for technical evaluations could be formed. In spite of this simulation and detailed data presentation, there was criticism and distrust on the part of the public. At the inquiry, it was stated that the noise and number index was unsuitable as a noise disturbance measure, and that despite present intentions, subsequent development would cause a major environmental problem. It is concluded that even greater clarity is needed on the part of those assessing noise impact so as to avoid spreading doubt and dismay. K.K.

**A86-32450**

**TOMORROW'S WEATHER - NEW ACCURACY IN FORECASTING**

G. GRAFF High Technology (ISSN 0277-2981), vol. 6, April 1986, p. 27-35.

Projects designed to enhance the accuracy of routine and long-range forecasts and to guarantee early detection of such hazards as tornadoes and wind shear are presented. The Program for Regional Observing and Forecasting Services (PFOFS) aims to overcome conventional forecasting barriers by covering a limited geographical region and by processing the available data more rapidly. One component of PROFS, the advanced Doppler radar, is incorporated into a weather detection effort called Nexrad, whose purpose is to spot severe storms far earlier than is possible with conventional radar. Tornadoes can be spotted well in advance, as well as wind shear. The weather tracking system McIDAS is discussed together with projects designed to enhance air safety, such as the Airport Weather Observing System and the Airport Surface Observing System. Satellite-borne lasers will be used to monitor upper-air activity, and increased accuracy in long-range forecasting will be provided by the Tropical Oceans and Global Atmosphere project. By the turn of the century, it is predicted that two-week forecasts will have the kind of specificity now associated with two-day forecasts. K.K.

**A86-32788*#** Michigan Technological Univ., Houghton.

**TURBULENCE FOR FLIGHT SIMULATION**

G. TREVINO (Michigan Technological University, Houghton) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 348, 349. NASA-supported research. Previously cited in issue 07, p. 1078, Accession no. A86-19738. refs

**N86-23159*#** Oklahoma Univ., Norman. National Severe Storms Lab.

**ANALYSIS OF AIRBORNE DOPPLER LIDAR, DOPPLER RADAR AND TALL TOWER MEASUREMENTS OF ATMOSPHERIC FLOWS IN QUIESCENT AND STORMY WEATHER Contractor Report, 27 Apr. 1982 - 31 Jul. 1985**

H. B. BLUESTEIN, R. J. DOVIAK, M. D. EILTS, E. W. MCCAUL, R. RABIN, A. SUNDARA-RAJAN, and D. S. ZRNIC Washington NASA Feb. 1986 178 p refs

(Contract NAS8-34749)

(NASA-CR-3960; NAS 1.26:3960) Avail: NTIS HC A09/MF A01 CSCL 04B

The first experiment to combine airborne Doppler Lidar and ground-based dual Doppler Radar measurements of wind to detail the lower tropospheric flows in quiescent and stormy weather was conducted in central Oklahoma during four days in June-July 1981. Data from these unique remote sensing instruments, coupled with data from conventional in-situ facilities, i.e., 500-m meteorological tower, rawinsonde, and surface based sensors, were analyzed to enhance understanding of wind, waves and turbulence. The purposes of the study were to: (1) compare winds mapped by ground-based dual Doppler radars, airborne Doppler lidar, and anemometers on a tower; (2) compare measured atmospheric boundary layer flow with flows predicted by theoretical models; (3) investigate the kinematic structure of air mass boundaries that precede the development of severe storms; and (4) study the kinematic structure of thunderstorm phenomena (downdrafts, gust fronts, etc.) that produce wind shear and turbulence hazardous to aircraft operations. The report consists of three parts: Part 1, Intercomparison of Wind Data from Airborne Lidar, Ground-Based Radars and Instrumented 444 m Tower; Part 2, The Structure of the Convective Atmospheric Boundary Layer as Revealed by Lidar and Doppler Radars; and Part 3, Doppler Lidar Observations in Thunderstorm Environments. Author

**N86-23997#** Lockheed Missiles and Space Co., Palo Alto, Calif. Research and Development Div.

**NUMERICAL GENERATION OF 3D CURVILINEAR COORDINATE SYSTEMS AND COMPUTATIONAL GRIDS FOR AIRCRAFT CONFIGURATIONS Final Technical Report, May 1982 - Jul. 1984**

P. D. THOMAS and A. K. WHITNEY Mar. 1985 22 p

(Contract F49620-82-C-0065)

(AD-A162249; LMSC/F035606; AFOSR-85-1058TR) Avail: NTIS HC A02/MF A01 CSCL 12A

This report describes the progress in research on the properties of the Lockheed 3-D elliptic grid generation procedure and improvement of its capabilities for treating complex geometric features characteristic of aircraft configurations. Two areas of weakness in the original technique relate to the fundamentally important capability for generating curved-surface grids as a necessary prerequisite for generating 3-D space grids. These weaknesses were: (1) difficulties associated with the limitations of Cartesian coordinates for describing convex surfaces; and problems in controlling the orthogonality of the grid near boundaries. The bulk of the first year's research resulted in development of a generalized system of elliptic grid generation equations that allow both the surface and the grid to be described in terms of an arbitrary system of curvilinear coordinates. Research in the second year was concerned primarily with the problem of grid orthogonality near boundaries. Three approaches investigated to improve the control that the user has over the angle at which grid lines intersect the boundaries were: (1) refinement of the original techniques; (2) development of techniques for marching from a given boundary using the angle as an initial condition; and (3) derivation of a fourth-order system that permits additional boundary conditions on the grid intersection angle. GRA

**N86-24090*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**STATISTICAL ANALYSIS OF DIRECT-STRIKE LIGHTNING DATA (1980 TO 1982)**
L. D. LEE, G. B. FINELLI, M. E. THOMAS, and F. L. PITTS Jan. 1984 30 p refs
(NASA-TP-2252; L-15686; NAS 1.60:2252) Avail: NTIS HC A03/MF A01 CSCL 04B

Electromagnetic measurements are being made during direct lightning strikes by NASA Langley Center using a specially instrumented F-106B aircraft. The research is to aid refinement, characterization, and understanding of the lightning-aircraft interaction process and the lightning hazards to aircraft. Statistical methods are applied to characterize some aspects of the lightning data obtained from 176 strikes to the aircraft. Specific attention is given to the problem of estimating the upper extreme quantiles of the distributions of peak-to-peak values for currents and rates of change in the magnetic and flux densities. A formal treatment via a general location-scale family of models allows the estimation method to be adapted to the realized shapes the distributions. The shapes are examined by probability plotting methods. Author

**N86-24091*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THE 1982 DIRECT STRIKE LIGHTNING DATA**
M. E. THOMAS and F. L. PITTS Mar. 1983 491 p refs
(NASA-TM-84626; NAS 1.15:84626) Avail: NTIS HC A21/MF A01 CSCL 04B

Wideband waveforms data which were obtained during the 1982 direct-strike lightning tests utilizing the NASA F106-B aircraft specially instrumented for lightning electromagnetic measurements. The aircraft was operated in a thunderstorm environment to elicit strikes to the aircraft during this testing period. Electromagnetic field data were recorded to both attached lightning and free field excitation of the aircraft. E.A.K.

**N86-24100#** Air Force Geophysics Lab., Hanscom AFB, Mass.
**STORM PRECIPITATION AND WIND STRUCTURE DURING AIRCRAFT STRIKE LIGHTNING EVENTS Environmental Research Papers**
A. R. BOHNE and A. C. CHMELA 24 May 1985 38 p
(AD-A162338; AFGL-TR-85-0121; AFGL-ERP-917) Avail: NTIS HC A03/MF A01 CSCL 04A

A limited set of in situ aircraft and ground-based radar data acquired during the 1981 and 1982 Joint Agency Turbulence Experiment are used to study the relationship of aircraft lightning strikes to storm precipitation, turbulence severity, and wind shear. The strikes are found to be strongly correlated with vertical drafts, predominantly downdrafts. The strikes were also well correlated with regions of strong turbulence. However, since most strong turbulence episodes were not associated with lightning, use of lightning location methods to locate hazardous turbulence within storms is considered unreliable. The strikes occurred in storm regions having radar reflectivity factor between 25 to 35 dBZ. These regions were generally on the boundaries of the dominant storm precipitation cores. Storm wind shear was frequently high in regions near aircraft strikes. The strong correlations with strong turbulence, downdraft boundaries, and precipitation core boundaries suggest that the strikes occurred in regions of charge separation. GRA

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## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-33184**
**INTERACTION BETWEEN CONTROLLING, PLANNING, AND FAULT MANAGING IN COMPLEX MAN-MACHINE SYSTEMS**
G. JOHANNSEN (Kassel, Gesamthochschule, West Germany) IN: A bridge between control science and technology. Volume 5 . Oxford and New York, Pergamon Press, 1985, p. 2541-2545. refs

The three main task categories in man-machine systems are controlling, planning, and fault managing which are briefly explained in the paper. Their interaction is illustrated schematically with a block diagram and further outlined using Rasmussen's cognitive levels of behaviour. Two paradigms, namely car driving and aircraft piloting, exemplify the nature of the interaction in more detail, partially based on experimental results. The state-of-the-art in modelling these task categories and their interaction is discussed with an emphasis on qualitative vs. quantitative models using control theory, artificial intelligence techniques, and fuzzy set theory. Model-based support and expert systems are mentioned as an important future application. Author

**N86-24215#** Navy Personnel Research and Development Center, San Diego, Calif.
**DEVELOPMENT OF A COMPUTER-MANAGED READINESS ASSESSMENT SYSTEM Final Report, Jul. 1982 - Sep. 1984**
W. F. THODE and P. G. BULETZA Dec. 1985 55 p
(AD-A162931; NPRDC-TR-86-8) Avail: NTIS HC A04/MF A01 CSCL 05I

Readiness of operational units, especially Fleet Air Reconnaissance Squadron TWO (VQ-2), is difficult to assess, particularly during operational cycles when the units are fulfilling their missions. This effort was conducted to develop a readiness training assessment system for VQ-2 to provide accurate, timely, and efficient assessments of the operational readiness of aircrew personnel while maintaining the highest possible state of readiness to perform the squadron's mission. The readiness training system for maintaining readiness and training data for VQ-2 aircrew personnel consists of: (1) a matrix for the EP-3E and the EA-3B aircraft of all the events that affect the readiness of the personnel assigned to the 10 crew positions in the EP-3E and the 5 crew positions in the EA-3B for each of the four VQ-2 mission area; (2) a computer-managed system to enter, process, store, and produce the readiness training manual that contains all VQ-2's references on training and readiness. Author (GRA)

**N86-24221#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**AN EXAMINATION OF THE LIFE SUPPORT EQUIPMENT DEVELOPMENT AND ACQUISITION PROCESS M.S. Thesis**
J. J. MOYER Sep. 1985 66 p
(AD-A162241; AFIT/GSM/XPX/85S-24) Avail: NTIS HC A04/MF A01 CSCL 15E

The process of life support equipment development and acquisition is examined. This research identified the how the present process works, and the problems of the process. The research was limited to the development and acquisition of life support equipment for tactical aircraft. However, most of the problems and steps of the process are shared by life support equipment programs for other users. The process was determined by referring to applicable regulations and interviewing people involved in the process. Problems were identified during interviews, and by examining the process as a whole. Seven problems are identified, of which five are considered correctable in the current defense acquisition framework. Four of the five problems deal with the management of the acquisition and development process, and combined indicate the lack of an integrated approach. Solutions were developed from suggestions obtained during the interviews and through qualitative analysis of the problems. An integrated solution is proposed in the recommendations. GRA

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# MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A86-30351

**1985 SUMMER COMPUTER SIMULATION CONFERENCE, CHICAGO, IL, JULY 22-24, 1985, PROCEEDINGS**

Conference sponsored by the Society for Computer Simulation. San Diego, CA, Society for Computer Simulation, 1985, 791 p. For individual items see A86-30352 to A86-30362.

Simulation methods are discussed, taking into account a microcomputer-based integrated simulation support (MISS) system, a production system analysis language for SLAM simulation modeling, model and program structuring for discrete systems simulation, a simulation language for microcomputers, an interactive continuous-system simulation language, and the concept of a general purpose model description language. Other topics explored are related to computer systems, simulation credibility and validation, physical and engineering sciences, data communication systems, chemical sciences, energy, biomedical simulation, environmental sciences, management and the social sciences, training and research simulators, government simulation/computation activities, CAD/CAM and manufacturing systems, artificial intelligence, simulation of discrete systems, and flight simulation systems. Attention is given to industrial automation, resource planning/scheduling, advanced mathematical techniques in chemical science, and dynamical systems in chemical engineering. G.R.

A86-31252

**ALL ABOUT SIMULATORS, 1984; PROCEEDINGS OF THE SIMULATORS CONFERENCE, NORFOLK, VA, APRIL 18-20, 1984**

V. AMICO, ED. and A. B. CLYMER, ED. Conference sponsored by the Society for Computer Simulation. La Jolla, CA, Society for Computer Simulation (Simulation Series. Volume 14, No. 1), 1984, 325 p. No individual items are abstracted in this volume.

Aspects of simulator development technology are explored, taking into account finite sets of nonlinear algebraic equations in real time, the numerical solution of differential algebraic equation systems, the design and implementation of a discrete time model for real time digital simulation, the development of a configuration management program for nuclear power plant simulators, and application software documentation standards for generating station simulators. Other subjects discussed are related to training with simulators, the simulator industry and its customers, and simulators for research/development/engineering. Attention is given to an electrical simulator for solving linear and nonlinear partial differential equations with an iterative method for refining approximate solutions, a simulator of an intelligent preprocessing image system, tactical software modeling for flight simulators, high-speed simulation of transients in nuclear power plants, a novel idea for microprocessor based simulation training, and a graduate curriculum for simulation/training professionals. G.R.

A86-31262

**CONFERENCE ON DECISION AND CONTROL, 23RD, LAS VEGAS, NV, DECEMBER 12-14, 1984, PROCEEDINGS. VOLUME 3**

Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1984, 560 p. No individual items are abstracted in this volume.

Various papers on decision and control in engineering are presented. The general topics considered include: estimation and control; parameter convergence issues in adaptive control; nonlinear systems; control of high-performance robots; networks; aerospace applications; stochastic processes and applications to detection, estimation, and information theory; new directions in theory and applications of distributed parameter systems; control and modeling of stochastic systems; and linear systems. Also addressed are: nonstandard approaches to estimation prediction and control; recent advances in adaptive control; symmetries in physics and control theory; robot path planning and control; decision theory; optimal control; decision and control in operations research; systems governed by PDEs or delay DEs; discrete time and sampled data systems; linear system algorithms. C.D.

A86-31312

**SMOOTHING PATCHED GRIDS**

D. C. WILSON (Florida, University, Gainesville) Computers and Fluids (ISSN 0045-7930), vol. 14, no. 1, 1986, p. 11-22. refs (Contract AF-AFOSR-83-0158)

The purpose of this paper is to indicate how smoothing techniques can be utilized in the area of grid generation. The focus of the paper is to show how one global grid can be patched together from a number of smaller ones. The procedure usually takes place in two steps. First, one global grid is patched together from a number of smaller ones, allowing for the possibility that the derivatives along common boundaries may not be continuous. The second step is to then approximate this grid by a smooth one in such a way that the essential structure of each patch is preserved. Author

A86-31656#

**WIND SHEAR ESTIMATION BY FREQUENCY-SHAPED OPTIMAL ESTIMATOR**

J. A. BOSSI (Washington, University, Seattle) and B. K. KIM Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 164-168. Research supported by Boeing Commercial Airplane Co. Previously cited in issue 10, p. 1447, Accession no. A84-25452. refs

A86-32079#

**GRUMMAN'S REAL TIME COMPUTING SYSTEM FOR AVIONICS TESTING**

C. SCHIANO and J. SILBERTO (Grumman Corp., Grumman Data Systems, Calverton, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 12 p.
(AIAA PAPER 86-9732)

The Automated Test System (ATS) presented integrates telemetry formatting, preprocessor, central processing, and display subsystems to yield a real time flight test analysis capability. ATS displays the results of engineering computations, speeds data turnaround, and allows the on-line modification of flight plans. The system monitors limit violations at the test director's console as they occur. The adaptive flight testing mode made possible by ATS has led to test director responses ranging from extreme caution to unprecedented flight envelope expansions. O.C.

A86-32081#

**HELICOPTER DATA ACQUISITION AND PROCESSING**

D. L. MARSHALL (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p.
(AIAA PAPER 86-9734)

The Fixed Base Data System (FBDS) is a modular architecture employing state-of-the-art technology for integrated data retrieval, flight monitoring, data processing, and analysis of helicopter test data. Modularity is a key feature of the system, allowing future expansion of both hardware and software. The goal of FBDS is to process 100 percent of the data required for safe test progress and at least 80 percent of the total data requirement, through complete documentation in near-real time. Real time operations include limit checking of all parameters, data compression, and fatigue damage identification. O.C.

**A86-32130#**

**MOBILE EXPERIMENTAL LABORATORY (MEL)**

R. D. TALMADGE (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9801)

This paper discusses an approach to providing a portable high powered computer system for data collection and processing. This system is designed to be used for field measurements and is built in a van. The purchase and modification of the van are discussed. Also the installation of the computer and other equipment is discussed. Author

**A86-32148#**

**TELEMETRY PROCESSING SYSTEM**

D. FANUS (Computer Sciences Corp., Lompoc, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 8 p.
(AIAA PAPER 86-9825)

Attention is given to a Telemetry Processing System that accepts PCM and FM/analog data streams from aircraft, space vehicles, or satellite systems at rates of up to 10 Mbits. The data streams are ingested by the telemetry preprocessor and subjected to synchronization, decommutation, time tagging, engineering unit conversion, derivation, and format conversion operations. A large selection of built-in, user-accessible algorithms and computational processes are available in the acquisition software. O.C.

**A86-32371**

**NEW CLASS OF FEATURES FOR PATTERN RECOGNITION AND IMAGE ANALYSIS**

W. C. CHOATE (Texas Instruments Computer Science Laboratory, Dallas) IN: Architectures and algorithms for digital image processing II; Proceedings of the Meeting, Los Angeles, CA, January 24, 25, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 179-184.

A class of features, called 'edge features', has been developed and applied to several problems of practical interest in image processing. These features are derived from a vector-valued function of the image called the 'edge spectrum'. The edge spectrum at coordinate (x,y) of the image describes the distribution of edge directions near (x,y). Several applications of edge features are discussed. One is considered in some detail. This application is to identify friendly aircraft descending for landing on an aircraft carrier. Identification is achieved by measuring wingspan - a good discriminant between the A6, A7, E2C and F14 aircraft. For this purpose an edge feature was designed for locating the wing tips in the image. Wingspan was converted to physical dimension using range information and the known parameters of the optical system. Author

**A86-33047**

**ESTIMATION OF THE STATE PARAMETERS OF NONLINEAR DYNAMIC SYSTEMS [OB OTSENKE PARAMETROV SOSTOIANIIA NELINEINYKH DINAMICHESKIKH SISTEM]**

V. I. GOLOVATENKO-ABRAMOV Priborostroenie (ISSN 0021-3454), vol. 29, Feb. 1986, p. 25-29. In Russian.

A method is presented for developing algorithms for estimating the state parameters of a nonlinear dynamic system in the case where the measurements and the input signal of the system are related through a nonlinear transformation. The mathematical model examined here is relevant to the problem of estimating the motion parameters of a flight vehicle whose control system uses inertial measuring instruments. V.L.

**A86-33127**

**MINIMAX FREQUENCY DOMAIN OPTIMIZATION OF MULTIVARIABLE LINEAR FEEDBACK SYSTEMS**

H. KWAKERNAAK (Twente, Technische Hogeschool, Enschede, Netherlands) IN: A bridge between control science and technology. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 19-24. refs

The minimax optimization of a linear feedback system sensitivity matrix and complement is generalized to the multivariable case. It is assumed that the plant has equally as many inputs as outputs, and it is noted that the solution is generally nonunique. Using the example of the plant which is constituted by the longitudinal dynamics of the CH-47 helicopter control system, the system is shown to produce realistic designs, and a solution of reduced degree is obtained at a lambda of approximately 4.74047. R.R.

**A86-33134**

**ON THE DEVELOPMENT OF EQUIOBSERVABLE FORMS WITH APPLICATION TO ADAPTIVE CONTROL**

H. OHTA (Nagoya University, Japan), M. M. GUPTA, and P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada) IN: A bridge between control science and technology. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 165-170. refs
(Contract NSERC-A-5625; NSERC-A-1080)

Three types of equiobservable forms are presented for linear time-invariant multivariable systems. These forms are developed using a nonminimal realization of a system and have properties that are useful in the analysis and design of state observation and parameter identification problems. By employing the third form, the state equation can be expressed by using filtered values generated from inputs and outputs in an algebraic form, and a new state observer can be obtained. To illustrate the application of the third form, a multivariable adaptive observer is also discussed. This observer is used to design a two-level adaptive flight controller for the pitch attitude control system of an aircraft. This approach appears to overcome some of the limitations that are inherent in the design of the linear optimal control and conventional adaptive control methods. In particular, the feedback gains of the optimal controller are updated using the estimation provided by the adaptive observer. The first-level of control consists of updated feedforward and optimal controllers. The second-level control is an error servo which provides fine compensation. Extensive simulation studies were carried out and some results are provided for the pitch attitude control of a STOL aircraft under two different flight conditions. Author

**N86-23309#** Joint Publications Research Service, Arlington, Va.

**PROGRAMMABLE HAND CALCULATORS IN AVIATION SPORT**

A. ROMANYUK *In its* USSR Report: Cybernetics, Computers and Automation Technology (JPRS-UCC-86-003) p 18-23 20 Mar. 1986 Transl. into ENGLISH from Krylya Rodiny (Moscow, USSR), no. 7, Jul. 1985 p 15-16
Avail: NTIS HC A04/MF A01

This research proposes that the MK-54 programmable hand calculator be used as a computer that calculates the points of participants in glider competitions. The cost of this and similar calculators (MK-56, BZ-34) varies between 50 and 100 rubles. The calculators feature a simple programming system, are easy to use and can muster most of the computational power required. It can execute point calculations in different glider class competitions when draws occur both in speed and distance competitions for any combination of finishers. The set-up time to run the calculations is less than 5 minutes, and the time required to calculate the results of one participant is less than 12 seconds. The program has been used in judging oblast competitions. A simplified flow chart of the algorithm used is presented, and a chart of the addressed registers is given. Author

**N86-23321*#** Stanford Univ., Calif. Center for Reliable Computing.
**DYNAMIC ASSERTION TESTING OF FLIGHT CONTROL SOFTWARE**
D. M. ANDREWS, A. MAHMOOD, and E. J. MCCLUSKEY Jul. 1985 25 p refs
(Contract NAG2-246)
(NASA-CR-176715; NAS 1.26:176715; SU-HICSS-19) Avail: NTIS HC A02/MF A01 CSCL 09B

Digital Flight Control System (DFCS) software was used as a test case for assertion testing. The assertions were written and embedded in the code, then errors were inserted (seeded) one at a time and the code executed. Results indicate that assertion testing is an effective and efficient method of detecting errors in flight software. Most errors are eliminate at an earlier stage in the development than before. B.G.

**N86-23322*#** Stanford Univ., Calif. Center for Reliable Computing.
**DYNAMIC ASSERTION TESTING OF FLIGHT CONTROL SOFTWARE**
D. M. ANDREWS, A. MAHMOOD, and E. J. MCCLUSKEY Jul. 1985 25 p refs Submitted for publication
(Contract NAG2-246)
(NASA-CR-176712; NAS 1.26:176712) Avail: NTIS HC A02/MF A01 CSCL 09B

Assertions are used to dynamically test fault tolerant flight software. The experiment showed that 87% of typical errors introduced into the program would be detected by assertions. Detailed analysis of the test data showed that the number of assertions needed to detect those errors could be reduced to a minimal set. The analysis also revealed that the most effective assertions tested program parameters that provided greater indirect (collateral) testing of other parameters. Author

**N86-23323*#** Stanford Univ., Calif. Center for Reliable Computing.
**A METHODOLOGY FOR TESTING FAULT-TOLERANT SOFTWARE**
D. M. ANDREWS, A. MAHMOOD, and E. J. MCCLUSKEY Nov. 1985 26 p refs
(Contract NAG2-246)
(NASA-CR-176713; NAS 1.26:176713; SU-CRC-TR-85-22; SU-CSL-TN-85-282) Avail: NTIS HC A03/MF A01 CSCL 09B

A methodology for testing fault tolerant software is presented. There are problems associated with testing fault tolerant software because many errors are masked or corrected by voters, limiter, or automatic channel synchronization. This methodology illustrates how the same strategies used for testing fault tolerant hardware can be applied to testing fault tolerant software. For example, one strategy used in testing fault tolerant hardware is to disable the redundancy during testing. A similar testing strategy is proposed for software, namely, to move the major emphasis on testing earlier in the development cycle (before the redundancy is in place) thus reducing the possibility that undetected errors will be masked when limiters and voters are added. Author

**N86-23325*#** Stanford Univ., Calif. Center for Reliable Computing.
**DYNAMIC ASSERTION TESTING OF FLIGHT CONTROL SOFTWARE**
D. M. ANDREWS, A. MAHMOOD, and E. J. MCCLUSKEY Aug. 1985 25 p refs
(Contract NAG2-246)
(NASA-CR-176716; NAS 1.26:176716; SU-CRC-TR-85-15; SU-CSL-TN-85-274) Avail: NTIS HC A02/MF A01 CSCL 09B

An experiment in using assertions to dynamically test fault tolerant flight software is described. The experiment showed that 87% of typical errors introduced into the program would be detected by assertions. Detailed analysis of the test data showed that the number of assertions needed to detect those errors could be reduced to a minimal set. The analysis also revealed that the most effective assertions tested program parameters that provided greater indirect (collateral) testing of other parameters. Author

**N86-23350*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**A COMBINED INTEGRATING AND DIFFERENTIATING MATRIX FORMULATION FOR BOUNDARY VALUE PROBLEMS ON RECTANGULAR DOMAINS Final Report**
W. D. LAKIN (Old Dominion Univ.) Mar. 1986 31 p refs Submitted for publication
(Contract NAS1-17070; NAS1-18107)
(NASA-CR-178074; ICASE-86-12; NAS 1.26:178074) Avail: NTIS HC A03/MF A01 CSCL 12A

Integrating and differentiating matrices allow the numerical integration and differential of functions whose values are known at points of a discrete grid. Previous derivations of these matrices were restricted to one dimensional grids or to rectangular grids with uniform spacing in at least one direction. Integrating and differentiating matrices were developed for grids with nonuniform spacing in both directions. The use of these matrices as operators to reformulate boundary value problems on rectangular domains as matrix problems for a finite dimensional solution vector is considered. The method requires nonuniform grids which include near boundary points. An eigenvalue problem for the transverse vibrations of a simply supported rectangular plate is solved to illustrate the method. Author

**N86-24233#** Spectra Research Systems, Inc., Vandenberg AFB, Calif.
**FEASIBILITY STUDY FOR A STATIC AIRCRAFT FLIGHT Final Technical Report, Oct. 1984 - Jun. 1985**
C. H. HIGHTOWER 14 Jun. 1985 55 p
(Contract N61339-84-C-0069)
(AD-A163129; SRS0069-0001; NAVTRASYSCEN-85-C-0069) Avail: NTIS HC A04/MF A01 CSCL 09B

The feasibility of embedding training software in modern flight aircraft to maintain pilot proficiency while parked was investigated. Candidate training scenarios critical to pilot performance were identified. Feasibility was demonstrated based on current and projected capabilities of the AYK-14 mission computers performing the weapons and navigation calculations in the Navy's F/A-18 Hornet. It was shown that the version 6 AYK-14 computer with dual single card processors (SCP's) would provide a suitable host for training software. The F/A-18 avionic and display systems are also shown to support the SAFES (Static Aircraft Flight Environment Simulator) concept. A number of candidate SAFES implementations are defined and one selected for feasibility demonstration remove fastener. Author (GRA)

**N86-24277*#** Carnegie-Mellon Univ., Pittsburgh, Pa.
**FAULT-FREE VALIDATION OF A FAULT-TOLERANT MULTIPROCESSOR: BASELINE EXPERIMENTS AND WORKOAD IMPLEMENTATION**
F. FEATHER, D. SIEWIOREK, and Z. SEGALL Apr. 1986 59 p refs
(Contract NAG1-190)
(NASA-CR-178075; NAS 1.26:178075) Avail: NTIS HC A04/MF A01 CSCL 09B

In the future, aircraft employing active control technology must use highly reliable multiprocessors in order to achieve flight safety. Such computers must be experimentally validated before they are deployed. This project outlines a methodology for doing fault-free validation of reliable multiprocessors. The methodology begins with baseline experiments, which test single phenomenon. As experiments progress, tools for performance testing are developed. This report presents the results of interrupt baseline experiments performed on the Fault-Tolerant Multiprocessor (FTMP) at NASA-Langley's AIRLAB. Interrupt-causing excepting conditions were tested, and several were found to have unimplemented interrupt handling software while one had an unimplemented interrupt vector. A synthetic workload model for realtime multiprocessors is then developed as an application level performance analysis tool. Details of the workload implementation and calibration are presented. Both the experimental methodology and the synthetic workload model are general enough to be applicable to reliable multi-processors besides FTMP. Author

**N86-24354#** Florida Univ., Gainesville.
**APPLICATIONS OF DIFFERENTIAL TOPOLOGY TO GRID GENERATION Final Report, 1 Jun. 1983 - 31 May 1984**
D. C. WILSON 25 Nov. 1985 46 p
(Contract AF-AFOSR-0158-83)
(AD-A162834; AFOSR-85-1165TR) Avail: NTIS HC A03/MF A01 CSCL 12A

The purpose of this paper is to indicate how smoothing techniques from Differential Topology can be applied to the area of algebraic grid generation in Computational Fluid Dynamics. The basic method is to patch together one global grid from a number of smaller ones. The smoothing theory allows one to blend the grid from one section into the grid of an adjacent one.
Author (GRA)

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## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-31010#**
**MANEUVERS FOR AIRCRAFT NOISE REDUCTION IN TAKEOFF, CLIMB, AND LANDING APPROACH OPERATIONS [MANIOBRAS PARA LA DILUCION DEL RUIDO AERONAUTICO EN LAS OPERACIONES DE DESPEGUE, SUBIDA Y APROXIMACION AL ATERRIZAJE]**
M. CUESTA IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Dec. 1985, p. 31-37. In Spanish. refs

The present evaluation of the characteristics and comparative effectiveness of maneuvers undertaken to reduce aircraft noise levels (due primarily to propulsion system acoustical characteristics) to mandated values gives attention to such representative aircraft as the B747, DC-10-30, B756/767, A310, and A320. Detailed results are presented from studies conducted to ascertain the noise levels generated by different reduced power takeoff regimes and steep landing approach descent trajectories. O.C.

**A86-31954**
**INTER-NOISE 85; PROCEEDINGS OF THE FOURTEENTH INTERNATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING, MUNICH, WEST GERMANY, SEPTEMBER 18-20, 1985. VOLUMES 1 & 2**
Conference sponsored by the International Institute of Noise Control Engineering and Bundesanstalt fuer Arbeitsschutz. Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz (Schriftenreihe der Bundesanstalt fuer Arbeitsschutz, Tagungsbericht, No. 39), 1985. Vol. 1, 759 p.; vol. 2, 774 p. For individual items see A86-31955 to A86-31966.

Various papers on the problem of noise are presented. The general topics addressed include: sources of noise emission; physical phenomena associated with noise; noise control elements; and the generation, transmission, isolation, and reduction of vibrations. Individual subjects discussed include: regulation and technical standards of noise control; noise-induced health disturbances; principles of machine noise reduction; characteristics and prediction of factory sound propagation; reduction of structure-borne noise; noise prediction and planning; noise emission data of machines and equipment; noise emission from road vehicles; noise from general aviation aircraft; noise emission from jet aircraft during takeoff; damping and acoustical radiation efficiency of carbon fiber-reinforced carbon epoxy plates. C.D.

**A86-31957#**
**NOISE EMISSION FROM JET AIRCRAFT DURING TAKE-OFF ROLL WITH RESPECT TO NOISE EXPOSURE CALCULATIONS**
C. SVANE, B. PLOVSING (Danish Acoustical Institute, Lingby, Denmark), and R. HIGGINSON (National Physical Laboratory, Teddington, England) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 1 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 315-318. Research sponsored by the European Economic Community, Danish National Agency of Environmental Protection and Danish Directorate of Civil Aviation.

The effect of forward speed on aircraft noise emission during takeoff ground-roll is studied. Preliminary results are reported for noise levels measured along a runway at the Copenhagen Kastrup Airport. The general trends of these findings is that noise levels decrease along the runway and that the effect of forward speed on noise emission is higher for low bypass ratio engines than for high bypass ratio engines. A prediction method suitable for incorporation into computer models for airport noise contours is discussed. C.D.

**A86-31959#**
**AIRCRAFT NOISE - DIFFERENT WAYS TO MONITOR THE NOISE LOAD**
G. BEKEBREDE (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 775-778.

Measures taken by the Dutch government to reduce aircraft-noise disturbances including the establishment of noise zones in which subsequent building is forbidden, while already existing homes are provided with noise insulation are discussed. To ensure accurate noise monitoring, the following recommendations were made by the NLR: (1) regular noise load calculations, utilizing aircraft noise and performance data, the air traffic mix, and flight route information; (2) flight track monitoring, performed by a computerized Flight Track and Aircraft Noise Monitoring System which identifies all aircraft deviating from the prescribed track (i.e., flying over congested regions); and (3) actual noise monitoring, to guard the noise level at a specific noise-sensitive area in close proximity to the airfield, such as a hospital. K.K.

**A86-31960#**
**CHARACTERISTICS OF BACK-RADIATED DEPARTURE NOISE AT SAN FRANCISCO INTERNATIONAL AIRPORT**
A. D. FEENER (San Francisco International Airport, CA) and W. K. CONNOR (Tracor Applied Sciences, Inc., Austin, TX) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 779-782.

In response to community concerns, the San Francisco International Airport initiated a study to determine the characteristics of disturbing noise, investigate the factors involved, and develop abatement procedures and policies. Field data were obtained at three sites (two elevated, one at runway level) with a tape recorder connected directly to the noise-monitoring-terminal microphone preamplifier output (which contains an A-weighing circuit). Two noise events were produced by departing planes, the first corresponding to takeoff roll, the second to climbout. Deck angle change, atmospheric refraction effects, and a decrease in ground attenuation are all contributing factors. A difference in spectral shape was found between the first event at a site situated at runway elevation and all other events. In the latter, greater excess attenuation from atmospheric and ground effects caused a concentration of energy in the low-frequency range. The question of the underestimation of impact by the monitoring system was subsequently addressed, and it was concluded that the noise level versus time patterns were unusual and call for special considerations in monitoring community noise. K.K.

**A86-31961#**

### NOISE OF MILITARY AIRCRAFT IN THE RANGE OF AIRPORTS AND AT LOW LEVEL FLIGHTS

V. HANS (Kaiserslautern, Universitaet, West Germany) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 783-786.

Military airport noise differs from that of civilian airports in its origins, characteristics, and potential effects. While civilian aircraft frequency spectra are characterized by amplitudes ranging from 75 dB(A) to 85 dB(A), military aircraft amplitudes can range from 70 dB(A) to 120 dB(A). The validity of the equivalent continuous sound level (Leq) as a measure of aircraft noise is evaluated, and the distribution of sound level versus time at various distances is indicated schematically for low-flying aircraft. The distribution reaches 75-80 dB(A) at 5 sec, after which the distribution goes to a plateau at 80-90 dB(A) in a period of 5-10 sec. Low level flights exhibit sound levels greater than 95 dB(A). Through an analysis of these distributions, plotted during landing approach and low-level flights, it is concluded that the Leq is a poor measure of aircraft disturbance. K.K.

**A86-31964#**

### COMPARISON OF DIFFERENT AIRCRAFT NOISE EXPOSURE INDICES IN FLIGHT CORRIDORS NEAR AIRPORTS

T. J. MEYER IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 1057-1060.

Noise indices based on the integration of exposed sound energy can be readily converted from one to another if the same measure for noise exposure is used. It is noted that dB(A) and PNdB can be converted satisfactorily if the distances and corresponding noise spectra of the noisiest starting and landing aircraft contained in the index are known. Approximations of these conversion relationships must take into account either the noise events of a single flight corridor, or the maximum noise levels of aircraft flying outside the flight corridor. They should be within the limits of noise levels of aircraft flying within the corridor. It is concluded that, before using these approximations, it must be determined whether or not an exact calculation with energy equivalent integration is necessary. K.K.

**A86-31965#**

### THE GERMAN-DUTCH WIND TUNNEL - AN AEROACOUSTICS EXPERIMENTATOR'S DREAM

H. HELLER, W. DOBRZYNSKI, W. SPLETTSTOESSER, and K. SCHULTZ (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 1091-1094.

The German-Dutch Wind Tunnel/DNW, when used in the acoustic mode, provides a realistic environment for aeroacoustic testing and high-quality data. Two research projects are discussed: (1) helicopter noise research, which concerns itself with high speed impulsive noise and blade/vortex interaction impulsive noise; and (2) propeller noise research. The data obtained proved to be excellent, and in the case of propeller noise research, such data could not have been obtained through flight tests. K.K.

**A86-31966#**

### PROGRESS TOWARDS INTERNATIONAL STANDARDISATION OF AIRCRAFT NOISE CONTOUR CALCULATIONS

R. F. HIGGINSON (National Physical Laboratory, Teddington, England) IN: Inter-noise 85; Proceedings of the Fourteenth International Conference on Noise Control Engineering, Munich, West Germany, September 18-20, 1985. Volume 2 . Dortmund, West Germany, Bundesanstalt fuer Arbeitsschutz, 1985, p. 1413-1415.

There is a need for standardization in noise contour calculations as evidenced by the fact that there is disagreement between nations, and within nations over the following: (1) the data base of individual aircraft noise and performance information; (2) the model formulas used; and (3) the noise index by which output is expressed. Though none of the current efforts being directed towards standardization are addressing the question of noise indices, three international organizations are making headway, the ECAC, the SAE, and the ICAO. The ECAC has established a format for basic aircraft noise and performance information; the SAE has published a prediction method for lateral attenuation of noise during aircraft takeoff and landing; and the ICAO has developed a method of deriving basic noise data and computing noise contours. K.K.

**A86-32312**

### THE DEVELOPMENT OF DICHROMATED GELATIN FOR HOLOGRAPHIC OPTICAL ELEMENT APPLICATIONS

R. W. EVANS (Pilkington Bros., PLC, Research and Development Laboratories, Ormskirk, England) IN: Applications of holography; Proceedings of the Meeting, Los Angeles, CA, January 21-23, 1985 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 302-304.

A practical industrial process has been developed for manufacturing holographic optical elements (HOEs), based on dichromated gelatin. The holograms consist of multilayer gelatin thin films having a fluctuating refractive index. The process of manufacturing the films involves recording light sensitive, dichromated gelatin layers and depositing them on to substrates. The films are in turn exposed to optical interference fringes which are produced using laser light. The pattern of light and dark fringes is recorded in the gelatin and transformed to a modulation of the refractive index by washing and swelling the gelatin in water, followed by rapid dehydration in a propanaol solution. Recent development work on thin films of 4-7 microns and thick films of about 60 microns has extended the diffraction efficiency near maximum for both planar and Bragg hologram types. The application of HOEs to Heads-Up Display systems for aircraft is discussed. I.H.

**A86-32778#**

### FINITE ELEMENT MODELING OF ACOUSTIC SINGULARITIES WITH APPLICATION TO PROPELLER NOISE

W. EVERSMAN (Missouri-Rolla, University, Rolla) and J. E. STECK Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 275-282. Previously cited in issue 01, p. 72, Accession no. A85-10842. refs

**A86-32783#**

### ACOUSTICAL DESIGN ECONOMIC TRADEOFF FOR TRANSPORT AIRCRAFT

A. BENITO (Madrid, Universidad Politecnica, Spain) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1247-1255) Journal of Aircraft (ISSN 0021-8669), vol. 23, April 1986, p. 313-320. Research sponsored by Iberia - Lineas Aereas de Espana. Previously cited in issue 22, p. 3298, Accession no. A84-45068. refs

**A86-32963*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PREDICTION OF ADVANCED PROPELLER NOISE IN THE TIME DOMAIN**

F. FARASSAT (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 578-584. Previously cited in issue 01, p. 73, Accession no. A85-10854. refs

**N86-22964*#** Rockwell International Science Center, Thousand Oaks, Calif.

**ULTRASONIC CHARACTERIZATION OF MICROSTRUCTURE IN POWDER METAL ALLOY**

B. R. TITTMANN, L. A. AHLBERG, and K. FERTIG *In* NASA. Lewis Research Center Analytical Ultrasonics in Materials Research and Testing p 31-47 Jan. 1986 refs
(Contract W-7405-ENG-82)
Avail: NTIS HC A16/MF A01 CSCL 20A

The ultrasonic wave propagation characteristics were measured for IN-100, a powder metallurgy alloy used for aircraft engine components. This material was as a model system for testing the feasibility of characterizing the microstructure of a variety of inhomogeneous media including powder metals, ceramics, castings and components. The data were obtained for a frequency range from about 2 to 20 MHz and were statistically averaged over numerous volume elements of the samples. Micrographical examination provided size and number distributions for grain and pore structure. The results showed that the predominant source for the ultrasonic attenuation and backscatter was a dense (approx. 100/cubic mm) distribution of small micropores (approx. 10 micron radius). Two samples with different micropore densities were studied in detail to test the feasibility of calculating from observed microstructural parameters the frequency dependence of the microstructural backscatter in the regime for which the wavelength is much larger than the size of the individual scattering centers. Excellent agreement was found between predicted and observed values so as to demonstrate the feasibility of solving the forward problem. The results suggest a way towards the nondestructive detection and characterization of anomalous distributions of micropores when conventional ultrasonic imaging is difficult. The findings are potentially significant toward the application of the early detection of porosity during the materials fabrication process and after manufacturing of potential sites for stress induced void coalescence leading to crack initiation and subsequent failure.
Author

**N86-23371*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**FREE JET FEASIBILITY STUDY OF A THERMAL ACOUSTIC SHIELD CONCEPT FOR AST/VCE APPLICATION-DUAL FLOW. COMPREHENSIVE DATA REPORT. VOLUME 1: TEST NOZZLES AND ACOUSTIC DATA**

B. A. JANARDAN, J. F. BRAUSCH, and A. O. PRICE Oct. 1984 501 p refs 2 Vol.
(Contract NAS3-22137)
(NASA-CR-174817; NAS 1.26:174817; R84AEB570) Avail: NTIS HC A22/MF A01 CSCL 20A

Acoustic and diagnostic data that were obtained to determine the influence of selected geometric and aerodynamic flow variables of coannular nozzles with thermal acoustic shields are summarized in this comprehensive data report. A total of 136 static and simulated flight acoustic test points were conducted with 9 scale-model nozzles The tested nozzles included baseline (unshielded), 180 deg shielded, and 360 deg shielded dual flow coannular plug configurations. The baseline configurations include a high radius ratio unsuppressed coannular plug nozzle and a coannular plug nozzle and a coannular plug nozzle with a 20-chute outer stream suppressor. The tests were conducted at nozzle temperatures and pressure typical of operating conditions of variable cycle engine.
Author

**N86-23372*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

**FREE-JET FEASIBILITY STUDY OF A THERMAL ACOUSTIC SHIELD CONCEPT FOR AST/VCE APPLICATION-DUAL STREAM NOZZLES. COMPREHENSIVE DATA REPORT. VOLUME 2: LASER VELOCIMETER AND SUPPRESSOR. BASE PRESSURE DATA**

B. A. JANARDAN, J. F. BRAUSCH, and A. O. PRICE Oct. 1984 234 p 2 Vol.
(Contract NAS3-22137)
(NASA-CR-174818; NAS 1.26:174818; R84AEB570) Avail: NTIS HC A11/MF A01 CSCL 20A

Acoustic and diagnostic data that were obtained to determine the influence of selected geometric and aerodynamic flow variables of coannular nozzles with thermal acoustic shields are summarized in this comprehensive data report. A total of 136 static and simulated flight acoustic test points were conducted with 9 scale-model nozzles. Aerodynamic laser velocimeter measurements were made for four selected plumes. In addition, static pressure data in the chute base region of the suppressor configurations were obtained to assess the influence of the shield stream on the suppressor base drag.
Author

**N86-24392*#** Bionetics Corp., Hampton, Va.

**THE RELATIVE EFFECT OF NOISE AT DIFFERENT TIMES OF DAY: AN ANALYSIS OF EXISTING SURVEY DATA**

J. M. FIELDS Washington NASA Apr. 1986 80 p refs
(Contract NAS1-16978; DTFA01-834-10564)
(NASA-CR-3965; NAS 1.26:3965) Avail: NTIS HC A05/MF A01 CSCL 20A

This report examines survey evidence on the relative impact of noise at different times of day and assesses the survey methodology which produces that evidence. Analyses of the regression of overall (24-hour) annoyance on noise levels in different time periods can provide direct estimates of the value of the parameters in human reaction models which are used in environmental noise indices such as LDN and CNEL. In this report these analyses are based on the original computer tapes containing the responses of 22,000 respondents from ten studies of response to noise in residential areas. The estimates derived from these analyses are found to be so inaccurate that they do not provide useful information for policy or scientific purposes. The possibility that the type of questionnaire item could be biasing the estimates of the time-of-day weightings is considered but not supported by the data. Two alternatives to the conventional noise reaction model (adjusted energy model) are considered but not supported by the data.
Author

**N86-24393*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CONSIDERATION OF SOME FACTORS AFFECTING LOW-FREQUENCY FUSELAGE NOISE TRANSMISSION FOR PROPELLER AIRCRAFT**

J. S. MIXSON and L. A. ROUSSOS Apr. 1986 28 p refs
(NASA-TP-2552; L-14994; NAS 1.60:2552) Avail: NTIS HC A03/MF A01 CSCL 20A

Possible reasons for disagreement between measured and predicted trends of sidewall noise transmission at low frequency are investigated using simplified analysis methods. An analytical model combining incident plane acoustic waves with an infinite flat panel is used to study the effects of sound incidence angle, plate structural properties, frequency, absorption, and the difference between noise reduction and transmission loss. Analysis shows that these factors have significant effects on noise transmission but they do not account for the differences between measured and predicted trends at low frequencies. An analytical model combining an infinite flat plate with a normally incident acoustic wave having exponentially decaying magnitude along one coordinate is used to study the effect of a localized source distribution such as is associated with propeller noise. Results show that the localization brings the predicted low-frequency trend of noise transmission into better agreement with measured propeller results. This effect is independent of low-frequency stiffness effects that have been previously reported to be associated with boundary conditions. Author

**N86-24394*#** DSMA Engineering Corp., Orlando, Fla.
**MODIFICATIONS TO THE 4X7 METER TUNNEL FOR ACOUSTIC RESEARCH: ENGINEERING FEASIBILITY STUDY Final Report**
Mar. 1986 83 p refs
(Contract NAS1-17892)
(NASA-CR-178079; NAS 1.26:178079; REPT-4054/R128) Avail: NTIS HC A05/MF A01 CSCL 20A

The NASA-Langley Research Center 4 x 7 Meter Low Speed Wind Tunnel is currently being used for low speed aerodynamics, V/STOL aerodynamics and, to a limited extent, rotorcraft noise research. The deficiencies of this wind tunnel for both aerodynamics and aeroacoustics research have been recognized for some time. Modifications to the wind tunnel are being made to improve the test section flow quality and to update the model cart systems. A further modification of the 4 x 7 Meter Wind Tunnel to permit rotorcraft model acoustics research has been proposed. As a precursor to the design of the proposed modifications, NASA is conducted both in-house and contracted studies to define the acoustic environment within the wind tunnel and to provide recommendations or the reduction of the wind tunnel background noise to a level acceptable to acoustics researchers. One of these studies by an acoustics consultant, has produced the primary reference documents that define the wind tunnel noise sources and outline recommended solutions. Author

**N86-24457#** United Technologies Research Center, East Hartford, Conn.
**COMPOSITE INTEGRAL RESPONSE SENSING Final Technical Report, Aug. 1982 - Mar. 1985**
J. R. DUNPHY, G. MELTZ, and R. M. ELKOW Sep. 1985 116 p
(Contract F08635-83-C-0287)
(AD-A163136; AD-E801242; UTRC/R85-926546-20; AFATL-TR-85-37) Avail: NTIS HC A06/MF A01 CSCL 20F

The investigation of a new concept for measurement of distributed strain is described. Implementation of the technique utilizes a fiber optic device with twin, coupled cores, a single input and a single output. Multiple wavelength operation of the sensor yields a diagnosis of the waveguide coupling perturbations imposed by mechanical disturbances. A general theory for the device has been derived in the form of an integral equation that relates the sensor core contrast to an arbitrary bending strain or curvature. In many cases of interest the curvature is small and slowly varying. For these conditions theory shows the core crosstalk spectrum is directly related to the Fourier transform of the strain distribution on a cantilevered beam. GRA

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**N86-23491#** Politecnico di Torino (Italy). Dept. of Aerospace Engineering.
**ACTIVITIES REPORT OF THE DEPARTMENT OF AEROSPACE ENGINEERING Annual Report, 1984**
Jul. 1985 35 p refs
Avail: NTIS HC A03/MF A01

Research activities in aeronautics and astronautics; fluid dynamics and propulsion; structures and materials; and systems engineering and management are summarized. Author (ESA)

**N86-24579#** Department of the Air Force, Washington, D.C.
**IMPACT OF RELIABILITY/MAINTAINABILITY (R/M) ON LOGISTICS COSTS FOR USAF AIRCRAFT**
A. J. SHERBO and J. LOCHBAUM 20 Sep. 1985 42 p Presented at the 19th Annual Department of Defense Cost Analysis Symposium, Leesburg, Va., 17-20 Sep. 1985
(AD-A162204) Avail: NTIS HC A03/MF A01 CSCL 15E

The purpose of this study is to develop some cost estimating relationships (CERs) that supports the contention that higher R&M results in lower logistics support costs, and can be used in a variety of ways. Our primary need is a methodology that enables us to quantify the impact of R&M changes or levels on existing and new aircraft in terms of logistics support costs. The CERs we are searching for need to be at the weapon system level as opposed to the subsystem or component level. GRA

**N86-24580#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**COMPARISON OF QUANTITY VERSUS QUALITY USING PERFORMANCE, RELIABILITY, AND LIFE CYCLE COST DATA. A CASE STUDY OF THE F-15, F-16, AND A-10 AIRCRAFT M.S. Thesis**
D. C. MERKER Sep. 1985 100 p
(AD-A162238; AFIT/GSM/LSQ/85S-23) Avail: NTIS HC A05/MF A01 CSCL 14A

The quantity versus quality issue is examined and a cost-effectiveness model designed to aid in evaluating it. This model incorporates mission effectiveness, readiness, and life cycle costs. The research effort was hinged around a case study comparison of the F-15, F-16, and A-10 aircraft. These aircraft were chosen because they represented varying system complexities and were used as surrogates to high, medium, and low complexity respectively. The comparisons made were intended to demonstrate the usefulness of using aircraft effectiveness, readiness and cost data in a mathematical cost-effectiveness model. The methodology followed combined multi-attribute value theory, aircraft readiness data, and aircraft life cycle cost information. The result was a series of cost-effectiveness ratios, and a cost-effectiveness curve which incorporated the three close air support aircraft. The cost-effectiveness curve provided the costs, adjusted by both effectiveness and readiness values. Author (GRA)

**N86-24584#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
**AN EVALUATION OF CPRA (COST PERFORMANCE REPORT ANALYSIS) ESTIMATE AT COMPLETION TECHNIQUES BASED UPON AFWAL (AIR FORCE WRIGHT AERONAUTICAL LABORATORIES) COST/SCHEDULE CONTROL SYSTEM CRITERIA DATA M.S. Thesis**
J. B. PRICE Sep. 1985 67 p
(AD-A162282; AFIT/GSM/LSY/85S-28) Avail: NTIS HC A04/MF A01 CSCL 14B

This thesis examined techniques used to derive estimates of the cost at completion for various research and development programs. The six methods examined were the methods used in the Cost Performance Report Analysis (CPRA) computer program to calculate estimates at completion. The analysis is based on a linear regression between the cost at completion for each technique available. The techniques were ranked by coefficient of determination and a general linear test was performed to test for equality among the regression lines. The results of this investigation indicate that an estimate at completion based upon weighted cost and schedule indices minimizes the unexplained error (as a percentage of total error) and is thought to be the superior forecaster of costs at completion. The general linear test for equality among the regression lines generated by the different techniques did not indicate the existence of commonality between regression lines. This means that each technique tested provided a unique estimate at completion. GRA

**N86-24592#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
**ACTIVITIES REPORT IN AEROSPACE IN WEST GERMANY Annual Report, 1984**
Aug. 1984 119 p In GERMAN; ENGLISH summary Original contains color illustrations
(ISSN-0070-3966) Avail: NTIS HC A06/MF A01

Research and development in air traffic management; aircraft technology; turbopropulsion and turbomachinery; nonnuclear energy systems; satellite communication and localization; remote sensing of the Earth; space systems; advanced technologies; and technology transfer are summarized. Project management, organization, DFVLR personnel, and financial development are presented. Author (ESA)

# SUBJECT INDEX

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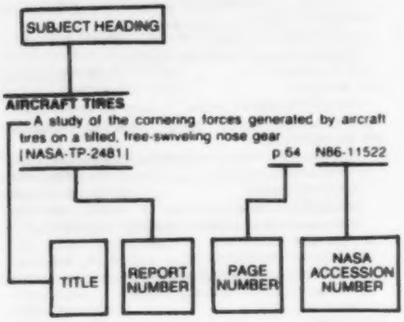

The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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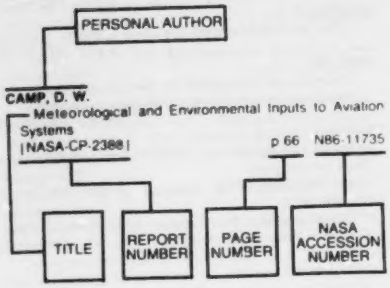

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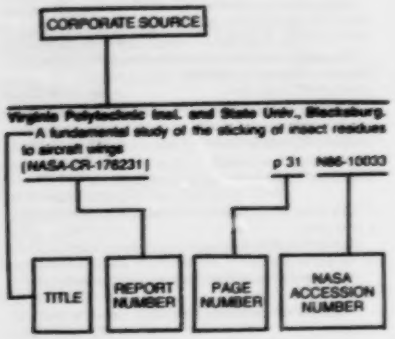
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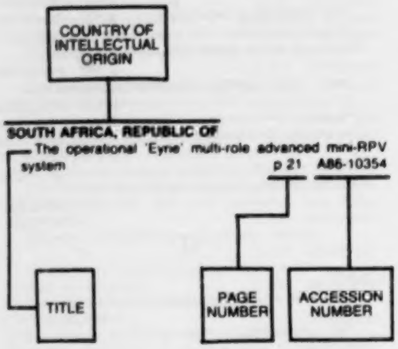
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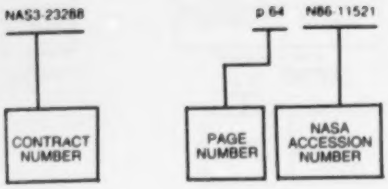

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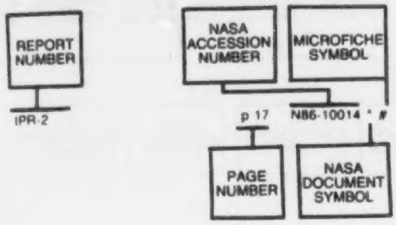

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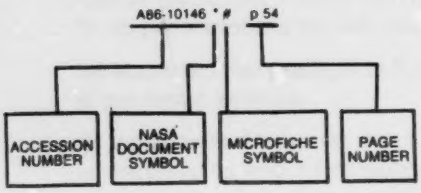

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NASA SP-7037(204)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

## (Supplement 204)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in August 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 419 reports, journal articles, and other documents originally announced in August 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

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# TYPICAL REPORT CITATION AND ABSTRACT

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ACCESSION NUMBER → **N86-10033*#** Virginia Polytechnic Inst. and State Univ., ← CORPORATE SOURCE
Blacksburg. Dept. of Chemistry.
TITLE → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
AUTHORS → N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs — PUBLICATION DATE
CONTRACT NUMBER → (Contract NAG1-300) — AVAILABILITY SOURCE
REPORT NUMBERS → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF ← PRICE CODE
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The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

# TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

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ACCESSION NUMBER → **A86-11041*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS** ← TITLE
AUTHOR → D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) ← AUTHOR'S AFFILIATION
CONFERENCE TITLE — AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs ← CONFERENCE DATE
(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

# AERONAUTICAL ENGINEERING

## A Continuing Bibliography (Suppl. 204)

SEPTEMBER 1986

## 01

## AERONAUTICS (GENERAL)

**A86-35163#**

**DEVELOPMENT TRENDS IN THE CASE OF HIGH-PERFORMANCE AIRCRAFT [ENTWICKLUNGSTENDENZEN BEI HOCHLEISTUNGSFLUGZEUGEN]**

K. H. HEILMANN (Bundesministerium der Verteidigung, Bonn, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 33 p. In German.
(DGLR PAPER 85-106)

The present paper is mainly concerned with fighter aircraft. The design of the European Fighter Aircraft (EFA) and the U.S. Advanced Tactical Fighter (ATF) represents an initiation of fighter aircraft projects which are particularly suited for providing an illustration of the developments in the considered area. In a discussion of these development trends, relations to other types of aircraft in the civil and military sectors are also considered. The requirements which have to be satisfied to justify the initiation of a program for the development of a fighter are examined. Attention is given to new operational capabilities provided by new technologies, new tactics, the feasibility of combat against airborne targets at a distance of 70 km under all-weather conditions, requirements regarding an employment of additional technological advances, developments regarding flight mechanics and flight control, the continuation of a utilization of both fiber-reinforced and metallic materials, the characteristics of the engines of the future, advances related to avionics, and general technological development trends. G.R.

**A86-35448**

**COCKPIT AND CABIN CREW COORDINATION AND COMMUNICATION**

N. KOAN (Association of Flight Attendants, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 189-193.
(SAE PAPER 851918)

Methods for improving cockpit/crew coordination and communication are examined. FAA recommendations and bulletins for enhancing crew interaction are described. The need for crew members to understand each others' duties, standardized emergency procedures, clarified sterile cockpit procedures, joint training of crew members, and independently powered communication equipment to ensure safe flights is discussed. I.F.

**A86-35601**

**AMERICAN HELICOPTER SOCIETY, ANNUAL FORUM, 41ST, FORT WORTH, TX, MAY 15-17, 1985, PROCEEDINGS**

Alexandria, VA, American Helicopter Society, 1985, 881 p. For individual items see A86-35602 to A86-35615, A86-35617 to A86-35665.

The present conference considers topics in the fields of helicopter dynamics, avionics, propulsion systems, acoustics, handling qualities, helicopter design configurations and aerodynamics, helicopter airframe structures and materials, helicopter manufacturers' product support services, test and evaluation techniques, helicopter rotor icing phenomena and deicing methods, manufacturing and product assurance methods, and helicopter crashworthiness. Attention is given to tilt-rotor aircraft stability test results, hover performance and crashworthiness, hingeless rotor gust response and stability, X-wing helicopter performance potential in naval applications, the aerodynamics of circulation control rotors, robotics in helicopter manufacturing, and composite structural damage assessment methods. O.C.

**A86-35983**

**CLASSIFICATION OF FLIGHT VEHICLES ACCORDING TO THE TYPE OF PROPULSION - DETERMINATION OF THE TYPE AND NUMBER OF LIFT SOLUTIONS [KLASSIFIKATSIIA LETATEL'NYKH APPARATOV PO VIDU DVIZHITELEI OPREDELENIE VIDA I CHISLA NESUSHCHIKH RESHENII]**

M. A. GURIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 33-39. In Russian. refs

**A86-36939**

**FLIGHT SIMULATION/SIMULATORS; PROCEEDINGS OF THE AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985**

Congress and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-634), 1985, 81 p. For individual items see A86-36940 to A86-36947.
(SAE SP-634)

The conference presents papers on the role of flight simulation in helicopter crew station design, changes in engineering flight simulation, and the application of the optimal control model to the design of flight simulation experiments. Also considered are the capabilities of airborne and ground-based flight simulation, alternatives to the high cost and the long time associated with typical flight simulation efforts, and the impact of Ada on simulators. Additional papers cover the simulation of aircraft components for training purposes and the effects of visual-cue dominance hierarchies on simulator design. K.K.

**N86-24652#** National Aeronautics and Space Administration, Washington, D.C.

**SELECTIONS FROM FLUG REVUE UND FLUGWELT INTERNATIONAL. A. ON THE BORDER OF TIME-HYPERSONIC FLIGHT. B. NASA PROGRAMS PAVE THE WAY FOR THE HYPERSONIC AIRCRAFT. C. SHUTTLE FLIGHT 61-B; CONSTRUCTION IN SPACE. D. FASTER THAN A BULLET; HYPERSONIC MILITARY AIRCRAFT**

H. PENNER, K. MUELLER, H. MULLER, G. WANGE, and N. LYNN May 1986 40 p Transl. into ENGLISH of Flug Revue and Flugwelt International (West Germany), Feb. 1986 p 9-22 and 46-50 Transl. by SCITRAN, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-88418; NAS 1.15:88418) Avail: NTIS HC A03/MF A01 CSCL 01B

Planned research and future developments in hypersonic aircraft, including possible military applications of hypersonic transport aircraft are discussed. NASA's development of hypersonic aircraft is discussed. Other topics include an overview of the 61-B Space Shuttle mission that pertains to the construction of space structures. Author

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-34160**

**THE INDUCED DOWNWASH AND LIFT ON A WING OF HIGH ASPECT RATIO IN UNSTEADY MOTION**

P. WILMOTT (Oxford University, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Feb. 1986, p. 63-72. Research supported by the Admirality Research Establishment. refs

An unsteady lifting line theory for a general motion of a wing of high aspect ratio is presented. The analysis parallels that of Van Dyke (1964) in his solution for the steady lifting line by the method of matched asymptotic expansions but is complicated by the shedding of transverse vortices associated with variation of circulation with time. Expressions are found for the downwash due to three-dimensional (finite span) effects and the lift on the wing. Calculation are presented for a wing of elliptic planform following a curved path. Author

**A86-34411#**

**INTRABLADE VELOCITY MAPPING IN TRANSONIC FAN PASSAGES OF GAS TURBINE**

M. C. WILLIAMS (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) IN: International Symposium on Laser Anemometry, 2nd, Miami Beach, FL, November 17-22, 1985, Proceedings . New York, American Society of Mechanical Engineers, 1985, p. 19-26. refs

Characterization of the aerodynamics of the flows within gas turbine intrablade passages requires the development of sensitive laser Doppler velocimeters, data acquisition systems capable of efficiently and accurately handling substantial quantities of data, and appropriate methods of post test data analysis and display to maximize the value of the recorded data. Pratt and Whitney developed a confocal LDV which was first employed in the mid 1970's for gas turbine intrablade studies. Experience gained through the instrument's use in several programs coupled with recent advances in optical coating technology formed the basis for a redesign which has recently been completed. The performance of this refined instrument has been demonstrated in a NASA sponsored fan study in which approximately 200 million valid velocity signals were detected and recorded. This study, the data acquisition system employed, and post test data reduction and presentation methods are reviewed. A novel recently developed data format which permits a three-dimensional depiction of intrablade air flows is also discussed. Author

**A86-34485**

**RISING OF THE FERRIE POINT ON THE WINDWARD SIDE OF DELTA WINGS [O VSPLYVANII TOCHKI FERRI NA NAVETRENNOI STORONE V-OBRAZNYKH KRYL'EV]**

N. A. OSTAPENKO (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 287, no. 2, 1986, p. 295-298. In Russian. refs

The position of the Ferrie singularity point on the windward side of a delta wing in supersonic flow (Mach 3) is examined. It is established that, depending on the flow regime, this point can be situated at the point of discontinuity of the transverse contour of the wing, or it can rise from the wing surface to the bow shock in the flow symmetry plane. Conical-flow restructuring in the presence of a Mach shock configuration is found which is connected with the fact that streamlines that have passed through an oblique/straight shock system are associated with smaller spherical losses of total pressure than streamlines that have passed through a bridge-shaped shock. B.J.

**A86-35082**

**FATIGUE LIFE IN A COUPLED PROBLEM CONCERNING THE MOTION OF A FLEXIBLE WING [USTALOSTNAIA DOLGOVECHNOST' V SVIAZANNOI ZADACHE O DVIZHENII GIBKOGO KRYLA]**

B. A. ERSHOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1986, p. 122, 123. In Russian. refs

A method is presented for calculating the fatigue life of a flexible wing moving at a supersonic velocity in a turbulent atmosphere. In accordance with the method proposed here, the fatigue life is calculated using a formula in which the following parameters must be known: the Wohler curve parameters determined experimentally, parameters of an atmospheric turbulence model, parameters characterizing the random vibrations of the flexible wing, and flow parameters in a formula for the spectral density of wing vibrations. V.L.

**A86-35154#**

**DETERMINATION OF WING DEFORMATION IN WIND TUNNEL MODELS USING STRESS MEASUREMENT SECTION TECHNOLOGY [BESTIMMUNG DER FLUEGELVERFORMUNG VON WINDKANAL-MODELLEN MIT HILFE DER DEHNGSMESSSTREIFEN-TECHNIK]**

T. WOLF (Darmstadt, Technische Hochschule, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 19 p. In German. refs
(DGLR PAPER 85-091)

A procedure using stress measurement section technology to control elastic wing deformation in wind tunnels is described. This method permits the deformation to be determining during wind tunnel tests without exact knowledge of the load distribution. An example of the method's application is presented. C.D.

**A86-35167#**

**ANALYTIC REPRESENTATION OF STEADY AND UNSTEADY AERODYNAMIC COEFFICIENTS OF MODERN HELICOPTER ROTORS [ANALYTISCHE DARSTELLUNG DER STATIONAEREN UND INSTATIONAEREN AERODYNAMISCHEN BEIWERTE MODERNER HUBSCHRAUBERROTOREN]**

U. LEISS and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 20 p. In German. refs
(Contract BMFT-LFF-83408)
(DGLR PAPER 85-114)

The development of modern highly stressed helicopter rotors requires an accurate knowledge of the dynamic and aerodynamic properties. Unsteady processes can be the cause for very long times of computation. With the objective to overcome these difficulties, the present investigation provides a universal model for the calculation of the aerodynamic forces and moments of a rotor blade. A modular, not too large structure, is needed for the employment of the flight-mechanics real-time simulation and for design and optimization objectives. Time-consuming computational procedures are replaced by simple theories and empirical parameters with aerodynamic significance. Attention is given to relations between forces and moments and the new dimensionless aerodynamic coefficients, steady flow, separated displacement flow, separated cyclic flow, supersonic flow, transonic flow, a comprehensive model of the steady flow, unsteady flow, a comparison of the obtained data with experimental values and other procedures, three-dimensional effects, and the analytic integration of differential forces and moments. G.R.

**A86-35171#**

### A COMPARISON OF SOLUTIONS OF THE COMPLETE POTENTIAL EQUATION AND THE EULER EQUATIONS FOR THE TRANSONIC FLOW AROUND THE DFVLR-F4-WING [VERGLEICH VON LOESUNGEN DER VOLLSTAENDIGEN POTENTIALGLEICHUNG UND DER EULERGLEICHUNGEN FUER DIE TRANSSONISCHE UMSTROEMUNG DES DFVLR-F4-FLUEGELS]

G. WICHMANN, R. RADESPIEL (DFVLR, Brunswick, West Germany), and S. LEICHER (Dornier GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 19 p. In German. refs
(DGLR PAPER 85-121)

In the context of the design of transonic wings for modern transport aircraft, reliable computational procedures are needed to verify design objectives and to predict performance limits. The present investigation is concerned with a study of the characteristics and suitability of currently available computational methods, taking into account an employment in the case of the DFVLER-F4-wing, which has been designed for an aircraft of the type Airbus A310. The results obtained with procedures for the study of the flow around wings are discussed and compared, giving attention to the solution of the potential equation on the basis of the finite-difference and finite-volume schemes. A time-marching approach has been used for the solution of the Euler equations. G.R.

**A86-35172#**

### A VORTEX LATTICE METHOD FOR CALCULATING NONLINEAR AERODYNAMIC CHARACTERISTICS OF INTERFERING AIRFOILS [EIN WIRBELGITTERVERFAHREN ZUR BERECHNUNG NICHTLINEARER AERODYNAMISCHER CHARAKTERISTIKA VON INTERFERIERENDEN TRAGFLAECHEN]

CH. URBAN and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 12 p. In German. refs
(Contract DFG-WA-42413)
(DGLR PAPER 85-122)

A numerical method is presented for calculating nonlinear, steady, and unsteady interference effects in incompressible potential flow for individual and staggered airfoils with and without front and lateral edge flow separation. The velocity potential is represented by discretely distributed dipole panels of constant strength on the wings and free vortex surfaces. In addition to the kinematic boundary conditions at the flat, thin wings, the remaining boundary conditions are implicitly fulfilled using the singularity model. The problem is solved using a time-dependent, stepped procedure in which the free vortex sheets form suddenly and evolve to a stationary state. The results of the flow interferences are illustrated for individual airfoils and wing-wing configurations. C.D.

**A86-35253**

### INVISCID VORTEX-STRETCHED TURBULENT SHEAR-LAYER FLOW COMPUTED AROUND A CRANKED DELTA WING

A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) and C. J. PURCELL (ETA Systems, Inc., St. Paul, MN) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 2, Mar.-Apr. 1986, p. 139-144.

A numerical simulation technique that evaluates the inviscid, turbulent flow-field, which develops around a wing at the high Reynolds number of free-flight conditions, is described. The development of a database using the transfinite interpolation method of Eriksson (1982) to construct a boundary-conforming O-O type mesh and Euler equations to form an artificial viscosity model is examined. Simulation data demonstrating the flow for a twisted, cranked-and-cropped delta wing are discussed. I.F.

**A86-35633*** Continuum Dynamics, Inc., Princeton, N. J.

### A NEW APPROACH TO THE FREE WAKE PROBLEM FOR HOVERING ROTORS

D. B. BLISS, D. A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ), and T. R. QUACKENBUSH (Princeton University, NJ) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 463-477. refs
(Contract NAS2-11730)

In the present approach to the hovering rotor free wake problem, an influence coefficient solution method is used to find that rotor wake solution which is steady in a reference frame that rotates with the blades; this scheme solves directly for the conditions of free wake equilibrium by a procedure that does not involve time-stepping and the associated use of numerical damping or special convergence methods. The solution method has been implemented in a hover wake computer program having a three-part wake model for the tip vortex. All three wake regions are represented by the new Basic Curved Vortex Elements. Sample hover calculations are presented for single blade and multiblade rotors. O.C.

**A86-35634**

### APPLIED AERODYNAMICS OF CIRCULATION CONTROL AIRFOILS AND ROTORS

E. O. ROGERS, A. W. SCHWARTZ, and J. S. ABRAMSON (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 479-490.

For a lifting/stoppable circulation control airfoil rotor, the critical flight condition of minimum available lift occurs in the 0.85-1.10 advance ratio range. Analysis of the aerodynamic flowfield for each blade element at the critical flight condition indicates that the airfoils operate in a low speed, highly yawed environment at a negative angle-of-attack. These data furnish guidelines for the proper design of airfoils and for the assessment of their performance. Recent tests of circulation control airfoils have further defined the stall boundaries and the influence of airfoil geometry on optimal operating conditions. O.C.

**A86-35636*** United Technologies Research Center, East Hartford, Conn.

### HOVERING ROTOR AIRLOAD PREDICTION USING A FULL POTENTIAL FLOW ANALYSIS WITH REALISTIC WAKE GEOMETRY

T. A. EGOLF and S. P. SPARKS (United Technologies Research Center, East Hartford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 515-530. refs
(Contract NAS2-11150)

A three-dimensional, full potential flow analysis with realistic hover wake geometry is presented for the prediction of hovering rotor airloads. The method of analysis is based on the concept of matching inner and outer domain solutions in three dimensions. The inner domain nonlinear solution is obtained using a finite difference analysis and the outer domain solution is based on prescribed wake methodology. This formulation which includes three-dimensional wake influence, was initially validated using a fixed-wing analysis, and has been extended to hovering rotor flight. Detailed chordwise and spanwise loading results are compared with subsonic and transonic test results from two rotor configurations to illustrate the predictive capabilities of the analysis. The extension of the method to steady-level forward flight is also discussed. Author

**A86-35555*** Ohio State Univ., Columbus.

**THE AERODYNAMICS OF ROTOR BLADES WITH ICE SHAPES ACCRETED IN HOVER AND IN LEVEL FLIGHT**

J. D. LEE (Ohio State University, Columbus) and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 735-742. refs

Through a series of flights in artificial clouds, ice accretions on the main rotor of a UH-1H helicopter were documented in detail upon landing by silicone-rubber molds for both hover and level flights. Full scale reproductions of typical accretions in hover were fabricated by means of epoxy castings and used for a wind-tunnel test program. Surface static pressure distributions were recorded and used to evaluate lift and pitching moment increments while drag was determined by wake surveys. For comparison, accreted ice shapes are presented for two level flight cases as well as preliminary analytical predictions. Author

**A86-35855*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FLOW FIELD AND NEAR AND FAR SOUND FIELD OF A SUBSONIC JET**

K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH) Journal of Sound and Vibration (ISSN 0022-460X), vol. 106, April 8, 1986, p. 1-16. refs

Flow and sound field data are presented for a 2.54 cm diameter air jet at a Mach number of 0.50 and a Reynolds number of 300,000. Distributions of mean velocity, turbulence intensities, Reynolds stress, spectral components of turbulence as well as of the near field pressure, together with essential characteristics of the far field sound are reported. This detailed set of data for one particular flow, erstwhile unavailable in the literature, is expected to help promoote and calibrate subsonic jet noise theories. 'Source locations' in terms of the turbulence maxima, coupling between the entrainment dynamics and the near pressure field, the sound radiation paths, and the balance in mass, momentum and sound energy fluxes are discussed. The results suggest that the large scale coherent structures of the jet govern the 'source locations' by controlling the turbulence and also strongly influence the near field pressure fluctuations. Author

**A86-35925**

**VELOCITY DISTRIBUTION AROUND A WING IN A WIND TUNNEL VERIFICATION OF A CALCULATION METHOD BY MEANS OF A LASER ANEMOMETER [ROZKLAD PREDKOSCI WOKOL PLATA UMIESZCZONEGO W TUNELU PRZEPLYWOWYM - WERYFIKACJA PEWNEJ METODY OBLICZENIOWEJ ZA POMOCA ANEMOMETRU LASEROWEGO]**

J. KONIECZKA and J. STELLER Instytut Maszyn Przeplywowych, Prace (ISSN 0079-3205), no. 88, 1985, p. 3-16. In Polish. refs

Velocity distribution around a wing between parallel walls is calculated theoretically with allowance for the effect of separation using an adaptation of Jacob's method. The results obtained are then compared with laser anemometer measurements conducted in a wind tunnel. It is found that the calculation method used here provides realistic velocity distributions for normal flow with or without separation. Details of the measurement procedure are given. V.L.

**A86-35979**

**CALCULATION OF THE DYNAMIC RESPONSE OF A FLIGHT VEHICLE USING A DISCRETE-CONTINUOUS MODEL [RASCHET DINAMICHESKOI REAKTSII LETATEL'NOGO APPARATA NA OSNOVE DISKRETNO-KONTINUAL'NOI MODELI]**

M. B. VAKHITOV, A. S. SAFONOV, and I. A. KUZNETSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 16-20. In Russian. refs

A numerical procedure is presented for calculating the dynamic response of a flight vehicle to external perturbations produced by changes in the kinematic parameters of the flight vehicle motion resulting from control actions or gusts. The elastic deformations of the lifting surfaces are determined in the context of a discrete-continuous model; the nonstationary aerodynamic load is determined using the method of discrete vortices. A solution is obtained in time steps, and results of calculations are presented. V.L.

**A86-35985**

**CALCULATION OF THE AERODYNAMIC CHARACTERISTICS OF THREE-DIMENSIONAL WINGS OF FINITE SPAN IN A POTENTIAL INCOMPRESSIBLE FLOW [RASCHET AERODINAMICHESKIKH KHARAKTERISTIK OB'EMNYKH KRYL'EV KONECHNOGO RAZMAKHA, OBTEKAEMYKH POTENTSIAL'NYM NESZHIMAEMYM POTOKOM]**

S. D. ERMOLENKO and E. A. KIAGUZOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 43-48. In Russian.

The problem of potential flow past a wing is solved using the discrete vortex method. The principles of the method are reviewed, and formulas are presented for calculating the distributed and integral aerodynamic characteristics. The efficiency of the method is illustrated by examples. The method described here is applicable to wings of both large (including infinite) and small aspect ratios corresponding to nonseparated flow. V.L.

**A86-35991**

**ANALYSIS OF A THREE-DIMENSIONAL STATIONARY TURBULENT BOUNDARY LAYER ON THE ROOT SECTION OF A WING WITHOUT ALLOWANCE FOR COMPRESSIBILITY [RASCHET TREKHMERNOGO STATSIONARNOGO TURBULENTNOGO POGRANICHNOGO SLOIA NA KORNEVOM OTSEKE KRYLA BEZ UCHETA SZHIMAEMOSTI]**

G. A. SHCHEKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 72-76. In Russian. refs

A procedure is presented for calculating a three-dimensional stationary boundary layer in the laminar, transition, and turbulent flow regions on wings. As an example, calculations are carried out for a three-dimensional stationary boundary layer on the upper surface of the root section of a swept wing. With the exception of the separation region, the results are found to be in good agreement with data in the literature. V.L.

**A86-35994**

**GROUP STUDIES OF EQUATIONS OF THE LAMINAR BOUNDARY LAYER ON A ROTATING WING [GRUPPOVYE ISSLEDOVANIIA URAVNENII LAMINARNOGO POGRANICHNOGO SLOIA NA VRASHCHAIUSHCHEMSIA KRYLE]**

M. A. DARAGAN and S. A. DERBENEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 81-84. In Russian.

A group analysis is made of the unsteady laminar boundary layer on a rotating wing, a problem relevant to many aircraft engineering applications. Invariant solutions are obtained which, in certain particular cases, simplify the analysis of the initial system of equations by reducing by one the number of independent variables. The results of the study provide a way to obtain similar invariant solutions in some other cases. V.L.

**A86-36201**

### ANALYTICAL TOOLS FOR SYSTEMATIC TRANSONIC DESIGN

H. SOBIECZKY (DFVLR, Institut fuer Theoretische Stroemungsmechanik, Goettingen, West Germany) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 309-326. refs

Special transonic flows are illustrated on the basis of near-sonic model equations, in order to generate both test cases for numerical methods and simple, educational models of observed phenomena in high speed aircraft and turbomachine components. The 'fictitious gas' technique employed was originally used to find special solutions to the transonic partial differential equations; the addressing of practical requirements then led to the refinement of the method for application in numerical analysis algorithms. Such algorithms will become increasingly valuable if systematic three-dimensional configurational design can rest on mature numerical codes as well as on a better understanding of three-dimensional flow phenomena. O.C.

**A86-36202**

### INVERSE METHOD WITH GEOMETRIC CONSTRAINTS FOR TRANSONIC AEROFOIL DESIGN

J. M. FRAY, J. W. SLOOFF, J. W. BOERSTOEL, and A. KASSIES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 327-339. refs

An engineering method for the design of aerofoils having a prescribed pressure distribution in subsonic or transonic flow is described. The method is based on an iterative procedure of 'residual-correction' type. In each iteration step, the difference between a current and a target pressure distribution (residual) is determined by a fast (multi-grid) finite-volume full-potential code. Corrections to the geometry driving the pressure residual to zero are determined by a global, inverse, thin-aerofoil theory based method for the subsonic part of the flow field, and by means of a local, inverse, wavy-wall theory based formula for the supersonic part of the flow field. The determination of the geometry correction has been formulated as a minimization problem in the sense that pressure distribution and geometry requirements may be balanced in a weighted least squares sense. The method is described briefly, including the basic mathematical/physical formulation and the main computational aspects. The capabilities of the method are illustrated by means of examples of aerofoil designs. Author

**A86-36206**

### APPLICATION OF ELLIPTIC CONTINUATION METHOD FOR TRANSONIC AEROFOIL DESIGN AND EXPERIMENTAL VERIFICATION

G. REDEKER, G. WICHMANN (DFVLR, Institut fuer Entwurfst Aerodynamik, Brunswick, West Germany), and H.-CHR. OELKER (Braunschweig, Technische Universitaet, Brunswick, West Germany) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 395-416. refs

With the aid of the elliptic continuation method, transonic aerofoils for two different purposes have been optimized. The design process is described and it is shown that the optimization is more difficult for higher design Mach numbers. The results of experimental investigations confirmed to good aerodynamic performances of the designed aerofoils, although no real shock-free pressure distributions could be achieved in the experiments and the highest aerodynamic efficiencies occurred always at higher lift coefficients, with pressure distributions already having shock waves. Author

**A86-36207**

### INVERSE DESIGN OF SUPERCRITICAL NOZZLES AND CASCADES

E. SCHMIDT and P. BERGER (Stuttgart, Universitaet, West Germany) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 417-432. refs

A computation method for the inverse design of supercritical cascades is described. It yields the flow field and the cascade geometry for a prescribed velocity distribution, which may be optimized by boundary-layer calculation. Some developments of the method for convenient application and high accuracy - automatic tuning of the upstream boundary distributions, local mesh refinement with emboxed regions for high resolution of steep gradients - are shown. Comparison between calculation and experiment of the complete flow field is made for a supercritical nozzle flow, and comparisons with another method for a turbine cascade. A supercritical compressor cascade and blades for a three-stage axial compressor have been designed. They produced lower losses and higher efficiency in comparison with conventional NACA blades. Author

**A86-36285**

### THE METHOD OF FUNDAMENTAL SOLUTIONS IN AERODYNAMICS. II APPLICATIONS TO THE THEORY OF LIFTING SURFACES IN SUPERSONIC FLOW

L. DRAGOS (Bucuresti, Universitatea, Bucharest, Rumania) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 37, no. 3, 1985, p. 221-230. refs

A new theory of the lifting surface in supersonic flow is given. The perturbation produced by a momentum source in uniform flow is determined, and the representation of the perturbation produced by the surface in the basic flow is obtained by assimilating the lifting surface by a continuous distribution of momentum sources of unknown intensity. The boundary conditions lead to the formula and the integral equation which determine the unknown functions. The method of fundamental solutions is shown to lead directly to the Homentcovschi representation and equation. The plane solution is obtained as a particular case. C.D.

**A86-36458**

### INVESTIGATION OF HEAT TRANSFER IN SEPARATION REGIONS IN SUPERSONIC FLOW IN A LAVAL NOZZLE [ISSLEDOVANIE TEPLOOBMENA V OTRYVNYKH OBLASTIAKH, OBTEKAEMYKH SVERKHZVUKOVYM POTOKOM V SOPLE LAVALIA]

E. G. ZAULICHNYI and V. M. TROFIMOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1986, p. 99-106. In Russian. refs

The paper describes experiments and an approximate calculation method intended to analyze heat transfer between a supersonic flow and a wall in a separation region arising on a cavity in the contour of the divergent part of a Laval nozzle. Attention is given to the behavior of the heat transfer coefficients on the cavity walls, and to the dependence of these coefficients on the longitudinal velocity gradient and Mach number at the separation point, as well as on the length of the horizontal wall of the cavity. In addition, a method for calculating heat transfer under the aforementioned conditions is proposed; the method assumes that a new boundary layer develops at the point of commencement of elevated pressure on the cavity wall, and takes into account the elevated level of flow turbulence in the attachment region. B.J.

**A86-36459**

**CHARACTERISTICS OF THE INTERACTION OF INTERFERENCE AND DIFFRACTION FLOWS AT SUPERSONIC VELOCITIES [OSOBENNOSTI VZAIMODEISTVIIA INTERFERENTSIONNYKH I DIFRAKTSIONNYKH TECHENII PRI SVERKHZVUKOVYKH SKOROSTIAKH]**

M. D. BRODETSKII, A. I. MAKSIMOV, and A. M. KHARITONOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1986, p. 106-116. In Russian. refs

Oil-soot and laser visualization techniques were used to investigate the supersonic flow past a plate with a longitudinal projection in the form of a combination of outer and inner bilateral corners. Experiments were conducted at freestream Mach numbers of 2.27, 3, and 4 for wide ranges of attack and slip angles. A substantially three-dimensional mixed interference-diffraction flow was observed. The interference of shocks and their interaction with boundary layers in the case of limited vertical-edge height are accompanied by the diffraction of inner shocks on the edge of the outer corner, with the formation of additional vortex systems. B.J.

**A86-37050*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**NONLINEAR LIFT CONTROL AT HIGH SPEED AND HIGH ANGLE OF ATTACK USING VORTEX FLOW TECHNOLOGY**

J. E. LAMAR (NASA, Langley Research Center, Hampton, VA) NATO, AGARD, Special Course on Fundamentals of Fighter Aircraft Design, Rhode-Saint-Genese, Belgium, Feb. 17-21, 1986, Paper. 24 p. refs

Nonlinear lift control at subsonic, transonic and low supersonic speeds owes its origin to the separated but organized vortical flows interacting with the wing upper surface. Since most of this flow originates near the wing or control-surface leading-edge, a variety of devices have been studied experimentally which interact with and/or control this flow in order to gain a beneficial effect. The benefits (effects) originally studied were only associated with lift enhancement. Whereas, now the studied benefits encompass performance increase, attention to changes in trimmed conditions and longitudinal stability, improvements in lateral stability, and the attendant variation with changing Mach number. For those devices that can be theoretically modeled, state-of-the-art computer codes have been used for device design and/or analysis. Comparisons at design and off-design conditions are presented for validation purposes. Author

**N86-24657*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**UNSTEADY TRANSONIC FLOW CALCULATIONS FOR WING-FUSELAGE CONFIGURATIONS**

J. T. BATINA Mar. 1986 16 p refs Presented at the 27th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986

(NASA-TM-87707; NAS 1.15:87707; AIAA-86-0862) Avail: NTIS HC A02/MF A01 CSCL 01A

Unsteady transonic flow calculations are presented for wing-fuselage configurations. Calculations are performed by extending the XTRAN3S unsteady transonic small-disturbance code to allow the treatment of a fuselage. Details of the XTRAN3S fuselage modeling are discussed in the context of the small-disturbance equation. Transonic calculations are presented for three wing-fuselage configurations with leading edge sweep angles ranging from 0 deg to 46.76 deg. Simple bending and torsion modal oscillations of the wing are calculated. Sectional lift and moment coefficients for the wing-alone and wing-fuselage cases are compared and the effects of fuselage aerodynamic interference on the unsteady wing loading are revealed. Tabulated generalized aerodynamic forces used in flutter analyses, indicate small changes in the real in-phase component and as much as a 30% change in the imaginary component when the fuselage is included in the calculation. These changes result in a 2 to 5% increase in total magnitude and a several degree increase in phase. E.A.K.

**N86-24658*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**A NUMERICAL ANALYSIS APPLIED TO HIGH ANGLE OF ATTACK THREE-DIMENSIONAL INLETS**

D. P. HWANG 1986 16 p refs Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; sponsored by AIAA, ASME, SAE, and ASEE

(NASA-TM-87298; E-3004; NAS 1.15:87298; AIAA-86-1627)

Avail: NTIS HC A02/MF A01 CSCL 01A

The three-dimensional analytical methods used to analyze subsonic high angle of attack inlets are described. The methods are shown to be in good agreement with experimental results for various three-dimensional high angle of attack inlets. The methods are used to predict aerodynamic characteristics of scarf and slotted-lip inlets. E.A.K.

**N86-24659*#** Boeing Commercial Airplane Co., Seattle, Wash.

**NATURAL LAMINAR FLOW FLIGHT EXPERIMENTS ON A SWEPT WING BUSINESS JET-BOUNDARY LAYER STABILITY ANALYSES Contractor Report, Sep. 1983 - Mar. 1985**

R. A. ROZENDAAL May 1986 98 p refs

(Contract NAG1-401)

(NASA-CR-3975; NAS 1.26:3975; D6-53071) Avail: NTIS HC A05/MF A01 CSCL 01A

The linear boundary layer stability analyses and their correlation with data of 18 cases from a natural laminar flow (NLF) flight test program using a Cessna Citation 3 business jet are described. The transition point varied from 5% to 35% chord for these conditions, and both upper and lower wing surfaces were included. Altitude varied from 10,000 to 43,000 ft and Mach number from 0.3 to 0.8. Four cases were at nonzero sideslip. Although there was much scatter in the results, the analyses of boundary layer stability at the 18 conditions led to the conclusion that crossflow instability was the primary cause of transition. However, the sideslip cases did show some interaction of crossflow and Tollmien-Schlichting disturbances. The lower surface showed much lower Tollmien-Schlichting amplification at transition than the upper surface, but similar crossflow amplifications. No relationship between Mach number and disturbance amplification at transition could be found. The quality of these results is open to question from questionable wing surface quality, inadequate density of transition sensors on the wing upper surface, and an unresolved pressure shift in the wing pressure data. The results of this study show the need for careful preparation for transition experiments. Preparation should include flow analyses of the test surface, boundary layer disturbance amplification analyses, and assurance of adequate surface quality in the test area. The placement of necessary instruments and usefulness of the resulting data could largely be determined during the pretest phase. Author

**N86-24661*#** Old Dominion Univ., Norfolk, Va.

**VAPOR-SCREEN FLOW-VISUALIZATION EXPERIMENTS IN THE NASA LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL Final Report**

G. V. SELBY Washington NASA May 1986 38 p refs

(Contract NGT-47-003-029)

(NASA-CR-3984; NAS 1.26:3984) Avail: NTIS HC A03/MF A01 CSCL 01A

The vortical flow on the leeward side of a delta-wing model has been visualized at several different tunnel conditions in the NASA Langley 0.3-Meter Transonic Cryogenic Tunnel using a vapor-screen flow-visualization technique. Vapor-screen photographs of the subject flow field are presented and interpreted relative to phenomenological implications. Results indicate that the use of nitrogen fog in conjunction with the vapor-screen technique is feasibile. Author

**N86-24663*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**NONISENTROPIC UNSTEADY THREE DIMENSIONAL SMALL DISTURBANCE POTENTIAL THEORY**

M. D. GIBBONS, W. WHITLOW, JR., (Purdue Univ., West Lafayette, Ind.), and M. H. WILLIAMS, (Purdue Univ., West Lafayette, Ind.) Apr. 1986 12 p refs Presented at the 27th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986
(Contract NAG1-372)
(NASA-TM-87726; NAS 1.15:87726; AIAA-PAPER-86-0863)
Avail: NTIS HC A02/MF A01 CSCL 01A

Modifications that allow for more accurate modeling of flow fields when strong shocks are present were made into three dimensional transonic small disturbance (TSD) potential theory. The Engquist-Osher type-dependent differencing was incorporated into the solution algorithm. The modified theory was implemented in the XTRAN3S computer code. Steady flows over a rectangular wing with a constant NACA 0012 airfoil section and an aspect ratio of 12 were calculated for freestream Mach numbers (M) of 0.82, 0.84, and 0.86. The obtained results are compared using the modified and unmodified TSD theories and the results from a three dimensional Euler code are presented. Nonunique solutions in three dimensions are shown to appear for the rectangular wing as aspect ratio increases. Steady and unsteady results are shown for the RAE tailplane model at $M = 0.90$. Calculations using unmodified theory, modified theory and experimental data are compared. Author

**N86-24664*#** United Technologies Corp., East Hartford, Conn.

**ALESEP. PART 2: A COMPUTER PROGRAM FOR THE ANALYSIS OF LEADING EDGE SEPARATION BUBBLES ON INFINITE SWEPT WINGS**

R. L. DAVIS 3 Feb. 1986 75 p refs
(Contract NAS1-16585)
(NASA-CR-178015; NAS 1.26:178015) Avail: NTIS HC A04/MF A01 CSCL 01A

A program called ALESEP is presented for the analysis of the inviscid-viscous interaction which occurs due to the presence of a closed laminar-transitional separation bubble on an airfoil or infinite swept wing. The ALESEP code provides an iterative solution of the boundary layer equations expressed in an inverse formulation coupled to a Cauchy integral representation of the inviscid flow. This interaction analysis is treated as a local perturbation to a known solution obtained from a global airfoil analysis; hence, part of the required input to the ALESEP code are the reference displacement thickness and tangential velocity distributions. Special windward differencing may be used in the reversed flow regions of the separation bubble to accurately account for the flow direction in the discretization of the streamwise convection of momentum. The ALESEP code contains a forced transition model based on a streamwise intermittency function, a natural transition model based on a solution of the integral form of the turbulent kinetic energy equation, and an empirical natural transition model. Author

**N86-24665*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ROTOR PERFORMANCE CHARACTERISTICS FROM AN AEROACOUSTIC HELICOPTER WIND-TUNNEL TEST PROGRAM**

D. R. HOAD, J. W. ELLIOTT, and N. M. ORIE May 1986 99 p refs
(Contract DA PROJ. 1L1-62209-AH-76)
(NASA-TM-87661; L-16078; NAS 1.15:87661; AVSCOM-TM-86-B-1) Avail: NTIS HC A05/MF A01 CSCL 01A

An investigation of helicopter rotor noise at model scale was conducted in the Langley 4 by 7 meter tunnel. The program described was the first of a planned three-phase project whose purpose was to examine the characteristic noise mechanism involved in main rotor/tail rotor interaction noise. This first phase was conducted with a main rotor only, in order to identify the characteristic noise generated by only the main rotor. The aerodynamic operating conditions of the rotor system were defined during the test. The acoustic data were properly referenced. Author

**N86-24666#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.

**THE BEHAVIOUR AND PERFORMANCE OF LEADING EDGE VORTEX FLAPS**

D. G. ELLIS Feb. 1986 79 p refs
(CAR-8601; ISBN-0-947767-34-7) Avail: NTIS HC A05/MF A01

A series of leading edge vortex flaps was studied in subsonic wind tunnel tests to determine the possibility of improving the lift/drag ratio. Various flap sizes and deflection angles, and trailing edge flap effects on leading edge vortex flap behavior were investigated. Lift/drag ratio improvements of more than 2% are found at moderate angles of attack. It is indicated that the vortex flap can improve the efficiency of slender wings when operating in aerodynamic environments which are governed by leading edge separation and flow. E.A.K.

**N86-24667*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**IN-FLIGHT MEASUREMENTS OF WING ICE SHAPES AND WING SECTION DRAG INCREASES CAUSED BY NATURAL ICING CONDITIONS**

K. MIKKELSEN, N. JUHASZ, R. RANAUDO, R. MCKNIGHT, R. FREEDMAN, and J. GREISSING May 1986 27 p refs
(NASA-TM-87301; E-3013; NAS 1.15:87301) Avail: NTIS HC A03/MF A01 CSCL 01A

Aircraft icing flight research was performed in natural icing conditions with a twin engine computer type STOL aircraft. In-flight measurements were made of the icing cloud environment, the shape of the ice accretion on the wing, and the corresponding increase in the wing section drag. Results are presented for three icing encounters. On one flight, the wing section drag coefficient increased 35 percent over the uniced baseline for cruise conditions while a 43 percent increase was observed at an aircraft angle of attack of 6.2 degrees. Author

**N86-24668#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INVESTIGATION OF ROLLING-UP AND INTERACTION OF LEADING-EDGE AND TRAILING-EDGE VORTEX SHEETS ON A SLENDER DELTA WING**

X. YIN, N. XIA, and G. DENG 15 Jan. 1986 24 p refs Transl. into ENGLISH from Lixue Xueboa (China), v. 16, no. 5, Sep. 1984 p 454-462
(AD-A163692; FTD-ID(RS)T-1041-85) Avail: NTIS HC A02/MF A01 CSCL 20D

The objective of this paper is to establish a simple two-dimensional theoretical model in an attempt to use a computer to numerically simulate the experimental results of Hummel regarding the rolling-up and interaction of the leading-edge and trailing edge vortex sheets on a delta wing. It was found experimentally that when the leading vortex is present the trailing-edge vortex sheet will roll up another vortex downstream from the trailing-edge. Furthermore, the circulation of the leading-edge vortex is opposite in direction to that of the trailing-edge vortex. The numerical results are in good agreement with the experimental pictures. GRA

**N86-24669#** Texas Univ., Austin. Dept. of Aerospace Eng and Eng. Mech.

**EXPERIMENTAL STUDY OF THE SUPERSONIC TURBULENT BOUNDARY LAYER ON A BLUNTED AXISYMMETRIC BODY**

**Final Report, 1 Aug. 1982 - 31 Jul. 1985**

D. S. DOLLING 30 Sep. 1985 25 p refs
(Contract DAAG29-84-M-0432)
(AD-A163736; ARO-22362.1-EG) Avail: NTIS HC A02/MF A01 CSCL 20D

Surface pressure distributions and turbulent boundary layer velocity profiles have been measured on a tangent-ogive cylinder model at small angles of attack (0-4.5 deg) in a high Reynolds number, Mach 3 airflow. The model wall temperature was approximately adiabatic. The measurements were made using pointed, tangent-hemisphere and flat-faced nose tips. The effects of tip blunting on the wind- and leeside velocity profiles, integral thicknesses, shape factor, power law exponent, skin friction coefficient and wake strength parameter are presented. It is shown that the results obtained using different geometry tips can be correlated using a bluntness length-scale obtained by integration of the local tip surface angle from the stagnation point to the point corresponding to shock detachment. GRA

**N86-24670#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**USE OF STATE ESTIMATION TO CALCULATE ANGLE-OF-ATTACK POSITION ERROR FROM FLIGHT TEST DATA M.S. Thesis**
T. H. THACKER Oct. 1985 99 p refs
(AD-A163962; AFIT/GAE/AA/85J-3) Avail: NTIS HC A05/MF A01 CSCL 20D

This thesis determined the position errors of an aircraft's angle-of-attack (AOA) sensor using state estimation with flight test data. The position errors were caused by local flow and upwash and were found to be a function of AOA and Mach number. The test aircraft used in this project was a T-38A Talon supersonic trainer from the USAF Test Pilot School configured with a Vought yaw and pitch system noseboom and an internal Aydin-Vector data acquisition system (DAS). The position errors were found by calculating the true AOA using equations of motion and DAS parameters. The data from the DAS were noise corrupted and had to be filtered. This was accomplished using state estimation in a Kalman filter. The estimated AOA was compared to the measured AOA from the noseboom sensor to obtain the position error. Accurate position errors were obtained, even in dynamic maneuvers. This method should be considered in future AOA error testing. The method was accurate enough to identify a hysteresis error in the T-38's AOA sensor of + or - 0.5 degrees, which was confirmed by ground calibration. GRA

**N86-25325** ESDU International Ltd., London (England).
**INCREMENTS IN AEROFOIL MAXIMUM LIFT COEFFICIENT DUE TO DEPLOYMENT OF VARIOUS HIGH-LIFT DEVICES**
Dec. 1985 36 p refs
(ESDU-85033; ISBN-0-85679-539-9; ISSN-0141-397X) Avail: ESDU

This data item ESDU 85033, an addition to the Aerodynamics Sub-Series, uses a semi-empirical method to predict the increase in the maximum lift coefficient from that of the basic aerofoil either estimated by the method of ESDU 84026 or obtained by test. Devices considered are plain leading-edge flaps, slats, Krueger flaps with or without vents, and plain and split trailing-edge flaps. The method applies to low speed flow for a practical range of Reynolds number and geometries, and also yields the zero lift incidence with the devices deployed. Comparison of prediction with test is made, and standard deviations are tabulated for each type of device. The overall accuracy for all devices over 141 experimental points is a standard deviation of 0.018 in maximum lift coefficient. Author

**N86-25328*#** Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
**TRANSONIC AIRFOIL ANALYSIS AND DESIGN IN NONUNIFORM FLOW**
J. F. CHANG and C. E. LAN Washington NASA Jun. 1986 84 p refs
(Contract NAG1-308)
(NASA-CR-3991; NAS 1.26:3991; CRINC-FRL-602-2) Avail: NTIS HC A05/MF A01 CSCL 01A

A nonuniform transonic airfoil code is developed for applications in analysis, inverse design and direct optimization involving an airfoil immersed in propfan slipstream. Problems concerning the numerical stability, convergence, divergence and solution oscillations are discussed. The code is validated by comparing with some known results in incompressible flow. A parametric investigation indicates that the airfoil lift-drag ratio can be increased by decreasing the thickness ratio. A better performance can be achieved if the airfoil is located below the slipstream center. Airfoil characteristics designed by the inverse method and a direct optimization are compared. The airfoil designed with the method of direct optimization exhibits better characteristics and achieves a gain of 22 percent in lift-drag ratio with a reduction of 4 percent in thickness. Author

**N86-25329#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**PITCH-LOCATION EFFECTS ON DYNAMIC STALL M.S. Thesis**
R. L. DIMMICK Dec. 1985 188 p refs
(AD-A164322; AFIT/GAE/AA/85D-4) Avail: NTIS HC A09/MF A01 CSCL 20D

Experimental investigations were conducted in the AFIT Smoke Tunnel to study the effects of pitch-location on dynamic stall. A NACA 0015 airfoil was rotated about four different locations at a constant angular rate and digital position and pressure information were recorded. This information was then converted into airfoil pressure distributions and integrated numerically to obtain airfoil force coefficients. Results of this investigation showed a direct relationship between the dynamic-stall angle of attack and the non-dimensionalized angular rotation rate, ND, defined as one-half the airfoil chord length times the angular rate divided by the freestream velocity. Based on the rotation points forward of the mid-chord, it was also shown that dynamic stall is delayed as the pitch location is moved aft from the leading edge. Experimental data was obtained for pitch locations of .08c, .25c, .50c and .61c and non-dimensional angular rates between .011 and .065. GRA

**N86-25534#** Joint Publications Research Service, Arlington, Va.
**HYPERSONIC FLOW AROUND A WING AT LARGE ANGLES OF ATTACK WITH DETACHED COMPRESSION JUMP Abstract Only**
V. N. GOLUBKIN and V. V. NEGODA *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-006) p 87 14 Mar. 1986 refs Transl. into ENGLISH from Izv. Akad. Nauk SSSR: Mekhanika Zhidosti i Gaza (USSR), no. 3, May-Jun. 1985 p 149-157 Original language document was announced in IAA as A85-44788
Avail: NTIS HC A06/MF A01

A study is made of the flow around a thin delta wing with finite delta angle at large angles of attack. A theory presented in earlier works describes a conical flow with a compression jump attached only at the apex of the delta wing. Possible conditions of flow around the wing at large angles of attack are classified. The results indicate that the asymptotic theory of the shock layer for a wing of finite span is the most general, since it describes all three qualitatively different flow conditions; with a compression jump attached to the leading edge, attached only to the apex or completely detached. A general solution is obtained which allows for nonequilibrium physicochemical processes and heat radiation of the gas at high temperatures. Author

**N86-25558#** Joint Publications Research Service, Arlington, Va.
**SUPERSONIC FLOW AROUND BLUNT PERFORATED SHIELDS Abstract Only**
S. V. GUVERNYUK, K. G. SAVINOV, and G. S. ULYANOV *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-001) p 2 24 Jan. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 1, Jan. - Feb. 1985 p 143-149 Original language document was announced in IAA as A85-28442
Avail: NTIS HC A06/MF A01

Experimental results are presented on flow past thin porous metallic disks and square plates at high angles of attack (75 to 90 deg), Mach numbers of 2.0 to 3.0 and Reynolds number of 2 to 4 million in a supersonic wind tunnel. The features characterizing flow past such screens are found to be determined by intense self sustaining gas injection into the base region. The dependence of the aerodynamic characteristics on the porosity coefficient of the screen is studied for a freestream Mach number of 3. B.J.

**N86-25560#** Joint Publications Research Service, Arlington, Va.
**FLOW AROUND DELTA WINGS WITH BROKEN-LINE LEADING EDGES Abstract Only**
A. I. SHVETS *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-001) p 3 24 Jan. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 1, Jan. - Feb. 1985 p 171-175
Avail: NTIS HC A06/MF A01

Two design concepts of delta wings for optimal performance at hypersonic velocities are compared on the basis of experimental data and analytic evaluation. Plain delta wings triangular in the plan view, with the dihedral angle ranging from 180 deg in a flat triangular wing to 0 deg in a completely folded one were considered. Tests were performed on such wings with 150 to 180 deg at angles of attack from -2 to +15 deg in a wind tunnel with the wind velocity varied over the Mach number 4 to 8. Tests were performed on five models of delta wing with broken line leading edges with a 70 deg sweepback angle of the nose and a 50 deg sweepback angle of the tail, all having the same 100 mm half span in the plan view but each having a different dihedral angle of 60, 100, 140, 180, and 220 deg respectively. Both the lift coefficient and the drag coefficient were measured in the wind tunnel at a wind velocity corresponding to the Mach number 3, for determining their dependence and the lift to drag ratio on the angle of attack. The aerodynamic characteristics of the wing models with the optimal dihedral angle were found to be better than those of flat wings with broken line leading edges. Author

**N86-25562#** Joint Publications Research Service, Arlington, Va.
**MOVEMENT OF FLEXIBLE WING AT SUPERSONIC VELOCITY UNDER INFLUENCE OF RANDOM GUST Abstract Only**
B. A. YERSHOV *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-001) p 4-5 24 Jan. 1986 Transl. into ENGLISH from Vestnik Leningradskogo Universiteta: Matematika, Mekhanika, Astronomiya (Leningrad, USSR), no. 1, Jan. - Mar. 1985 p 59-63
Avail: NTIS HC A06/MF A01

The motion of an elastic wing of infinite span in an ideal compressible fluid under the action of a turbulent stream is modeled by a random vertical gust. The unperturbed motion is the movement of a rigid wing at constant horizontal velocity greater than the speed of sound in the undisturbed stream. The perturbed motion is the deformation of the wing. The problem is reduced to an integro-differential equation in partial derivatives. The problem is one of connected aeroelasticity, such that the deformation of the elastic wing excited by the air stream changes the air stream itself. The present problem is determined by the wave equation for the excited velocity potential and the equation of oscillation of the infinite wing plate, related by the boundary condition on the wing. Author

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-33780**
**SETTING ACCEPTABLE LEVELS OF SAFETY FOR THE NATIONAL AIRSPACE SYSTEM**
A. C. BUSCH and B. F. COLAMOSCA (FAA, Technical Center, Atlantic City, NJ) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1985, p. 52-56.

The FAA is engaged in a major effort to safely reduce the vertical separation standard to 1,000 feet between aircraft flying above 29,000 feet, and to develop system performance requirements which, if met, will ensure safe operation of the National Airspace System. To accomplish this an overall program structure of defining risk/safety criteria, a risk assessment program, and a risk management program are proposed. Included in this effort is an extensive in situ data collection effort. Hopefully, the conclusion of this effort will result in providing to management the quantitative decision tools and information necessary to make the decision for the safe reduction of the vertical separation standard and to implement changes to the National Airspace System to support new separation procedures. Author

**A86-33799**
**PILOT ERROR ACCIDENTS - A TOTAL SYSTEM APPROACH TO ANALYSIS**
P. G. STRINGER and D. D. RILEY (Essex Corp., Alexandria, VA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1985, p. 526-530.

A total system approach (TSA) for evaluating aircraft/pilot performance and safety, and for recommending aircraft design improvements is described. The TSA involves an analysis of pilot error accident data in order to develop a model of task performance. The system elements of the TSA model, which include mission, aircraft characteristics, environment, pilot capacity, and cockpit interface, are examined. The model assesses the balance between flight requirements and pilot capabilities. The development of an aircraft and accident data management and analysis program is proposed. I.F.

**A86-35365*** Analytical Mechanics Associates, Inc., Mountain View, Calif.
**DESIGN OF AN ADVANCED FLIGHT PLANNING SYSTEM**
J. A. SORENSEN and T. GOKA (Analytical Mechanics Associates, Inc., Mountain View, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 663-668. refs
(Contract NAS1-17345)

The demand for both fuel conservation and four-dimensional traffic management require that the preflight planning process be designed to account for advances in airborne flight management and weather forecasting. The steps and issues in designing such an advanced flight planning system are presented. Focus is placed on the different optimization options for generating the three-dimensional reference path. For the cruise phase, one can use predefined jet routes, direct routes based on a network of evenly spaced grid points, or a network where the grid points are existing navaid locations. Each choice has its own problem in determining an optimum solution. Finding the reference path is further complicated by choice of cruise altitude levels, use of a time-varying weather field, and requiring a fixed time-of-arrival (four-dimensional problem). Author

**A86-35367**
**PRACTICAL CONSIDERATIONS IN OPTIMAL FLIGHT MANAGEMENT COMPUTATIONS**
S. LIDEN (Sperry Corp., Aerospace and Marine Group, Phoenix, AZ) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 675-681. refs

The relationships between cost index, speed, flight time, fuel burn, and wind are investigated via simulations of flight of a DC-10 aircraft, as controlled by a flight management computer system (FMCS), over a representative 1000 NM flight plan. In this context, a two-part procedure is described for achieving minimum total flight cost; that is, direct operating cost plus arrival error cost. First the optimum cost index and the associated optimum arrival time (which sometimes turns out to be the scheduled arrival time) are sought. A simple method for fine tuning the speed to achieve the desired arrival time is then described. The methods are practical to incorporate in the FMCS. Author

**A86-35368**

**TIME NAVIGATION BENEFITS IN EN ROUTE METERED ATC**

R. W. SCHWAB and R. L. ERWIN, JR. (Boeing Commercial Airplane Co., Seattle, WA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 682-686. refs

This paper evaluates benefits to be expected from an early use of Time Navigation (TNAV) capabilities now under engineering development for Flight Management Computer Systems (FMS) operating in the U.S. into airports where En Route Metering (ERM) is currently operational or is scheduled to become operational. The benefits estimates are based on the ability to define and fly fuel-efficient, ATC compatible profiles to meet metering objectives into busy terminal areas. Near-term benefits are quantified from simulation studies of two currently metered airports, Denver and Dallas-Ft. Worth, projected to all planned ERM airports. Consideration of frequency of obtaining nonconflicting 'TNAV Cleareances' is examined. The savings quantified are based on the use of improved delay absorption techniques using an enhanced FMS. Future operations of TNAV may provide additional fuel savings through reduction of system delay levels and the incorporation of optimization methods to maximize fuel savings. Author

**A86-35449**

**DEVELOPMENT OF AN AUTHORITATIVE AID TO WIND SHEAR TRAINING**

C. R. HIGGINS (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 195-197. (SAE PAPER 851919)

The development of an authoritative aid to provide pilots with wind shear training guidance is proposed. Analyses of accident data reveal that it is necessary to establish flight crew training requirements for handling wind shear. The need to coordinate meteorological, engineering, flight operation, and flight crew training data in order to produce the authoritative aid is discussed. I.F.

**A86-35450**

**UNITED AIRLINES WINDSHEAR TRAINING UPDATE**

D. A. SIMMON, JR. (United Airlines, Inc., Chicago, IL) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 199-208. (SAE PAPER 851920)

The formation of the United Airlines wind shear training program is described. The human engineering aspects of wind shear training and crew coordination are examined. Flight crew actions regarding wind shear involve: (1) avoidance of wind shear; (2) evaluation of the weather conditions; (3) following standard takeoff and landing techniques; (4) following precautions during takeoff and landing; and (5) recovery from wind shear. I.F.

**A86-35451**

**COCKPIT COMMUNICATION AND AIRCRAFT SAFETY - AN EMPIRICAL STUDY**

J. WOELFEL and B. STOVER (New York, State University, Albany) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985. Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 213-224. refs (SAE PAPER 851858)

Recent investigations into the cause of aircraft accidents have revealed that the way flight-crew members interact has a dramatic effect on the ultimate outcome of a flight. The Galileo System is presented as a research tool designed to measure attitudes within any cognitive system for a given population. The results of one Galileo study (conducted on general aviation crews) demonstrate that the average structure of flight crew attitudes is without defects or areas for concern. The study concluded by calling for caution in changing an attitude system that has served the aviation system well. K.K.

**A86-35452**

**FAULTY COCKPIT COMMUNICATION AS A FACTOR IN THE FAILURE OF FLIGHT 90**

D. A. COUCHMAN (New Mexico State University, Las Cruces) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 225-230. refs (SAE PAPER 851859)

The importance of cockpit communication is described by analyzing flight data. The relationship between poor cockpit communication and role differentiation, problem solving strategies, lack of decisive command, and crew attitude is investigated. The need for a good interface between cockpit automation and the crew is examined. The improvement of aviation safety through group interaction training is discussed. I.F.

**A86-35456**

**TWIN-ENGINE TRANSPORT EXTENDED RANGE OPERATIONS**

J. HOWELL (Air Line Pilots Assocation International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 389-395. (SAE PAPER 851960)

Design improvements recommended by pilots for extended range operations with twin-engine transport aircraft (ETOPS) are described. The need for hardware design changes in the fuel tank and the flight management computer system is examined. New standards for propulsion system reliability APUs, enroute alternate weather minima, validation flight, and status software are proposed. The advantages these recommendations will provide to ETOPS are discussed. I.F.

**A86-35609**

**FAA CERTIFICATION CRITERIA FOR LIGHTNING PROTECTION OF HELICOPTER DIGITAL ENGINE CONTROL**

R. L. VAUGHN (FAA, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 131-136. refs

'Change 2' to the FAA advisory circular 29-2, 'Certification of Transport Category Rotorcraft', concerns the lightning strike-related requirements for helicopters equipped with full authority digital engine control systems. Attention is presently given to the advisory circular's characterization of the worst case lightning environment, and the types of tests and analyses that are acceptable in lieu of a full scale, full level vehicle test. The pilot must be able to maintain helicopter operation through the worst case scenario. O.C.

**A86-35656*** Sikorsky Aircraft, Stratford, Conn.

**THE PERFORMANCE CHARACTERISTICS OF SIMULATED ICE ON ROTORCRAFT AIRFOILS**

R. J. FLEMMING (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH), and J. D. LEE (Ohio State University, Columbus) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 743-757. refs

Attention is given to the results of NASA-sponsored rotorcraft icing research which was aimed at the formulation of a predictive method for the computation of performance penalties due to rotor and airfoil icing. Parametric simulated ice test results obtained in wind tunnels are compared with those of other investigations. These comparisons indicate that proper design of simulated ice shapes can adequately represent ice on airfoil sections, with incremental lift, drag, and pitching moments matching those generated in icing wind tunnels. O.C.

**N86-24672*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LOADS AND MOTIONS OF AN F-106B FLYING THROUGH THUNDERSTORMS**

R. M. WINEBARGER May 1986 53 p refs
(NASA-TM-87671; L-16014; NAS 1.15:87671) Avail: NTIS HC A04/MF A01 CSCL 01C

Data are presented on loads and motions of a NASA F-106B airplane flying inside thunderstorms. No significant differences in piloting techniques were observed among the three pilots involved. It is indicated that airliners in normal operations occasionally encounter turbulence almost as severe as those encountered in these thunderstorm flights. E.A.K.

**N86-24673*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ICE DETECTOR Patent Application**

L. M. WEINSTEIN, inventor (to NASA) 31 Mar. 1986 14 p
(NASA-CASE-LAR-13403-1; NAS 1.71:LAR-13403-1; US-PATENT-APPL-SN-846429) Avail: NTIS HC A02/MF A01 CSCL 01C

An ice detector for aircraft that can accurately determine the presence and thickness of ice and control devices to remove it is proposed. A small depression on the surface of an aircraft structure is filled with a plastic or epoxy material. Two capacitance gauges and a temperature gauge are embedded in this material near the surface. When moisture forms on the surface the capacitance of each of the gauges changes. This signal combined with the signal from a temperature gauge determines whether the moisture is water or ice. If ice is present its thickness may be measured based on the output of the second capacitance gauge. Once the presence of ice is determined, the thickness is easily determined. The output of the device may be used to provide an indication to the pilot or to automatically control heating elements to remove the ice. Author

**N86-24674#** Naval Postgraduate School, Monterey, Calif.

**APPLICATION OF ARTIFICIAL INTELLIGENCE TO IMPROVE AIRCRAFT SURVIVABILITY M.S. Thesis**

W. L. DECKER Dec. 1985 76 p refs
(AD-A164172; AD-E750890) Avail: NTIS HC A05/MF A01 CSCL 06D

The hazards associated with the critical flight phases of civil as well as military flight operations can seriously degrade pilot efficiency, and therefore aircraft survivability, if the number or complexity of tasks that the pilot must manage exceeds his/her capabilities. This thesis explores the feasibility of applying artificial intelligence (AI) research to the construction of a Survivability Manager (SM) knowledge based system (KBS) that will assist the pilot by assuming a portion of the survivability task management load. The application of KBS principles to survivability management is illustrated using the normal and emergency management procedures for a hypothetical engine fuel supply system as a working example. Though the SM is not a reality today, there is considerable research in both AI and survivability enhancement studies to draw upon. It is recommended that a prototype be developed using currently available assets to further investigate the feasibility of the Survivability Manager. GRA

**N86-24675#** National Transportation Safety Board, Washington, D. C.

**AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORTS: DENVER, COLORADO, AUGUST 19, 1983; BLOUNTVILLE, TENNESSEE, JULY 16, 1983; TUCSON, ARIZONA, FEBRUARY 6, 1983, COCKEYSVILLE, MARYLAND, APRIL 28, 1984; AKRON, OHIO, SEPTEMBER 30, 1984; SEATTLE, WASHINGTON, OCTOBER 18, 1984; MIAMI, FLORIDA, NOVEMBER 11, 1983**

30 Sep. 1985 63 p
(PB85-910409; NTSB/AAR-85/01/SUM) Avail: NTIS HC A04/MF A01; HC also available on subscription, North American Continent price $60.00, all others write for quote CSCL 13L

Reports of eight separate aircraft accidents investigated by the National Transportation Safety Board are presented. The accident locations and their dates are as follows: Denver, Colorado, August 19, 1983; Blountville, Tennessee, July 16, 1983; Tucson, Arizona, February 6, 1983; Sioux Falls, South Dakota, December 20, 1983; Cockeysville, Maryland, April 28, 1984; Akron, Ohio, September 30, 1984; Seattle, Washington, October 18, 1984; and Miami, Florida, November 11, 1983. A brief containing the probable cause of accident is included for each case. GRA

**N86-25331#** Lockheed-California Co., Burbank.

**KRASH DYNAMICS ANALYSIS MODELING: TRANSPORT AIRPLANE CONTROLLED IMPACT DEMONSTRATION TEST Final Report, Jan. 1984 - Sep. 1984**

G. WITTLIN and B. LABARGE Mar. 1986 178 p refs Revised
(Contract DTFA03-84-C-00004)
(DOT/FAA/CT-85/9-REV; LR-30776-REV) Avail: NTIS HC A09/MF A01

A transport airplane Controlled Impact Demonstration (CID) test is analyzed with program KRASH. Prior to modeling the test conditions, supporting analysis of both narrow-body and wide-body transport airplane frame segments were modeled with KRASH and compared to existing test results. The results of the analysis are utilized as input data for the KRASH CID model. Prior to the CID test a narrow-body transport airplane was impacted with the ground, via a free fall drop, to obtain structure crush and damage data. The KRASH modeling of this test was used to refine the CID KRASH model. The CID KRASH model is exercised to obtain anticipated floor acceleration, underside crush, fuselage forces, and deflections. All KRASH modeling is performed utilizing current enhancement features. Recent KRASH85 coding changes; KRASH models and results for both narrow-body and wide-body transport airplane frame section drop tests; KRASH model and results for a narrow-body airplane drop test; KRASH model and results for a CID test; and conclusions based on the CID pre-test analysis results are presented. Author

**N86-25332#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.

**AIRCRAFT ACCIDENT REPORT: AIR CANADA FLIGHT 797, MCDONNELL DOUGLAS DC-9-32, C-FTLU, GREATER CINCINNATI INTERNATIONAL AIRPORT, COVINGTON, KENTUCKY, JUNE 2, 1983**

31 Jan. 1986 118 p
(PB86-910402; NTSB-AAR-86-02) Avail: NTIS MF A01; also available on subscription, North American Continent price HC $60.00/year; all others write for quote CSCL 01B

On June 2, 1983, Air Canada Flight 797, a McDonnell Douglas DC-9-32, of Canadian Registry C-FTLU, was a regularly scheduled international passenger flight from Dallas, Texas, to Montreal, Quebec, Canada, with an en route stop at Toronto, Canada. The flight left Dallas with 5 crewmembers and 41 passengers on board. About 1903, eastern daylight time, while en route at flight level 330, the cabin crew discovered a fire in the aft lavatory. After contacting air traffic control (ATC) and declaring an emergency, the crew made an emergency descent, and ATC vectored Flight 797 to the Greater Cincinnati International Airport, Covington, Kentucky. At 1920.09, eastern daylight time, Flight 797 landed on runway 27L at the Greater Cincinnati International Airport. As the pilot stopped the airplane, the airport fire department was in place and began firefighting operations. 23 passengers were not able to get out of the plane and died in the fire. The airplane was destroyed. GRA

## 03 AIR TRANSPORTATION AND SAFETY

**N86-25333#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
**AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORTS: CONCORD, CALIFORNIA, JULY 14, 1984; ATLANTA, GEORGIA, SEPTEMBER 24, 1984; JASPER, ALABAMA, DECEMBER 16, 1984; AVALON, CALIFORNIA, JANUARY 30, 1984; CHARLOTTESVILLE, VIRGINIA, FEBRUARY 17, 1984; KANSAS CITY, KANSAS, JANUARY 9, 1985**
31 Dec. 1985 46 p
(PB86-910410; NTSB-AAR-85-02-SUM) Avail: NTIS MF A01; also available on subscription, North American Continent price HC $60.00/year; all others write for quote CSCL 01B

The publication is a compilation of the reports of six separate aircraft accidents investigated by the National Transportation Safety Board. The accident locations and their dates are as follows: Concord, California, July 14, 1984; Atlanta, Georgia, September 24, 1984; Jasper, Alabama, December 16, 1984; Avalon, California, January 30, 1984; Charlottesville, Virginia, February 17, 1984; and Kansas City, Kansas, January 9, 1985. A Brief of Accident containing the probable cause is included for each case. GRA

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-33741#**
**NEW DEVELOPMENTS IN ANTENNAS OF CLASSICAL RADIO NAVIGATIONAL AND LANDING SYTEMS [NEUE ENTWICKLUNGEN VON ANTENNEN KLASSISCHER FUNKNAVIGATIONSUND LANDESYSTEME]**
G. GREVING (Standard Elektrik Lorenz AG, Stuttgart, West Germany) (URSI and Nachrichtentechnische Gesellschaft, Gemeinsame Tagung, Kleinheubach, West Germany, Oct. 7-11, 1985) Kleinheubacher Berichte (ISSN 0343-5725), vol. 29, 1986, p. 453-458. In German. refs

The development of three new high-performance antennas for the VOR (Very high frequency Omnidirectitonal Range) TACAN (Tactical Air Navigation), and ILS (Instrumentenlandesystem) navigational systems is reviewed. The objectives of the new antennas are discussed. The structure and function of the antennas are briefly described. Author

**A86-33988#**
**FIRST TESTS OF AN ONBOARD MLS RECEIVER [PREMIERS ESSAIS D'UN RECEPTEUR DE BORD MLS]**
A. CHAPELET and J.-P. MARGALA (LMT Radio Professionnelle, Boulogne-Billancourt, France) Revue Technique Thomson - CSF (ISSN 0035-4279), vol. 17, Sept. 1985, p. 591-615. In French.

The first European airborne testing of an MLS receiver, to replace the ILS in providing angular azimuth and elevation information, is reported at Bretigny-sur-Orge. Testing in November 1984 aboard the Nord 260 aircraft was conducted primarily on approach maneuvers at constant azimuth and elevation, but also on cross beam maneuvers and on runway centerline flights at constant height. Control Motion Noise (CMN) calculations, based on comparison between onboard MLS data and ground radar tracking data, were well within the maximum ICAO values. At runway threshold, the receiver azimuth function CMN is less than 0.02 degrees and the elevation function is less than 0.03 degrees. R.R.

**A86-35293**
**COMPUTER-CONTROLLED NAVIGATION FOR AEROMAGNETIC SURVEY FLIGHTS DURING THE GANOVEX IV ANTARCTIC EXPEDITION DURING THE SOUTHERN SUMMER OF 1984/85 [COMPUTER-KONTROLLIERTE NAVIGATION FUER AEROMAGNETISCHE VERMESSUNGSFLUEGE BEI DER ANTARKTISEXPEDITION GANOVEX IV IM SUEDSOMMER 1984/85]**
F.-J. HEIMES (Bochum, Fachhochschule, West Germany) Bildmessung und Luftbildwesen (ISSN 0006-2421), vol. 54, March 1986, p. 92-99. In German.

The role of the Computer Controlled Navigation System (CCNS) in the GANOVEX Antarctic expedition is described. The CCNS supplies computer-supported mission planning, exact steering information for the pilot on a CRT-type display, can command a camera, and records actual flight parameters. The functional principle of the CCNS is summarized, and experiences with CCNS during the Antarctic expedition are reviewed, including the contruction and operation of the transponder station and the flight operation. C.D.

**A86-35369*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SIMULATION OF TIME-CONTROL PROCEDURES FOR TERMINAL AREA FLOW MANAGEMENT**
M. ALCABIN, H. ERZBERGER, L. TOBIAS (NASA, Ames Research Center, Moffett Field, CA), and P. J. OBRIEN (FAA Technical Center, Atlantic City, NJ) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 687-695. refs

Simulations of a terminal area traffic-management system incorporating automated scheduling and time-control (four-dimensional) techniques conducted at NASA Ames Research Center jointly with the Federal Aviation Administration, have shown that efficient procedures can be developed for handling a mix of 4D-equipped and conventionally equipped aircraft. A crucial role in this system is played by an ATC host computer algorithm, referred to as a speed advisory, that allows controllers to maintain accurate time schedules of the conventionally equipped aircraft in the traffic mix. Results are of the most recent simulations in which two important special cases were investigated. First, the effects of a speed advisory on touchdown time scheduling are examined, when unequipped aircraft are constrained to follow fuel-optimized profiles in the near-terminal area, and rescheduling procedures are developed to handle missed approaches of 4D-equipped aircraft. Various performance measures, including controller opinion, are used to evaluate the effectiveness of the procedures. Author

**A86-35437**
**THE CONSIDERATION OF PILOT FACTORS IN DEVELOPMENT OF FUTURE COLLISION AVOIDANCE SYSTEMS**
G. P. BOUCEK, JR., W. D. SMITH, and T. A. PFAFF (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 93-102. refs
(SAE PAPER 851807)

Pilot factors affecting the development of collision avoidance systems are studied. The requirements and functions of a collision avoidance system are described. The need to design the avionics system to transmit relevant operational information to the crew is examined. The integration of the controls and displays of the system into the flight deck and the development of a pilot/machine interface are analyzed. The evaluation of the system considering pilot factors and the certification process are discussed. I.F.

**A86-35444**

**IN FLIGHT ACCESS TO MINIMUM VECTORING ALTITUDES - A PILOT'S PERSPECTIVE**

J. M. MCCORMICK, JR. (Air Line Pilots Association International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 159-171. refs

(SAE PAPER 851837)

The need for minimum vectoring altitude (MVA) data during in-flight is discussed. Various aircraft accidents caused by aircraft at incorrect altitudes, improper ATC clearances, or communication failures are described; these examples reveal the need for improved MVA information. The establishment of minimum safe altitude for instrument flight rules is examined. The advantages and disadvantages of a minimum safe altitude warning program and ground proximity warning system for improving ATC are analyzed. The inertial reference system combined with a navigation system data base, which produces a computer-generated moving-map display is studied. The use of a Mode-S Beacon system to provide timely and cost-effective MVA information to pilots is proposed. I.F.

**A86-35464**

**RADAR CHARACTERISTICS OF FLIGHT VEHICLES [RADIOLOKATSIONNYE KHARAKTERISTIKI LETATEL'NYKH APPARATOV]**

M. E. VARGANOV, IU. S. ZINOVEV, L. IU. ASTANIN, A. A. KOSTYLEV, A. IA. PASMUROV et al. Moscow, Izdatel'stvo Radio i Sviaz', 1985, 236 p. In Russian. refs

Methods for describing the scattering properties of flight vehicles and measuring their radar characteristics are reviewed, with particular attention given to the determination of the local and geometric characteristics of the scattering centers. The use of spatial processing of narrow-band signals (radioholography) for measuring local scattering characteristics is discussed, and the scattering properties of targets are analyzed for the case of complex and ultrawide-band signals. Methods for modeling dynamic and statistical radar characteristics are discussed in detail. V.L.

**A86-35608*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DEVELOPMENT AND FLIGHT TEST OF A HELICOPTER, X-BAND, PORTABLE PRECISION LANDING SYSTEM CONCEPT**

T. J. DAVIS, G. R. CLARY (NASA, Ames Research Center, Moffett Field, CA), J. P. CHISHOLM, and S. L. MACDONALD (Sierra Nevada Corp., Reno) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 121-130. Previously announced in STAR as N85-26721.

A beacon landing system (BLS) is being developed and flight tested as a part of NASA's Rotorcraft All-Weather Operations Research Program. The system is based on state-of-the-art X-band radar technology and digital processing techniques. The BLS airborne hardware consists of an X-band receiver and a small microprocessor, installed in conjunction with the aircraft instrument landing system (ILS) receiver. The microprocessor analyzes the X-band, BLS pulses and outputs ILS-compatible localizer and glide slope signals. Range information is obtained using an on-board weather/mapping radar in conjunction with the BLS. The ground station is an inexpensive, portable unit; it weighs less than 70 lb and can be quickly deployed at a landing site. Results from the flight-test program show that the BLS has a significant potential for providing rotorcraft with low-cost, precision instrument approach capability in remote areas. Author

**A86-35610**

**PRECISION IMC APPROACHES TO HELIPORTS USING COLLOCATED MLS**

S. SHOLLENBERGER, J. H. ENIAS (FAA, Technical Center, Atlantic City, NJ), and P. S. DEMKO (U.S. Army, Ft. Monmouth, NJ) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 137-143. refs

This paper addresses several factors which influence the application of MLS operations to heliports. Determination of MLS siting criteria and course widths are addressed. These factors, along with approach angle, deceleration distance, and control of approach speed ultimately determine precision approach speed ultimately determine precision approach decision height (DH). Test results presented in the paper show that the MLS elevation antenna should be located in front of the heliport to allow for adequate deceleration distance while permitting lowest possible DH. Test results also show that if the MLS must be collocated at the heliport, DH must increase. In this case, an azimuth course width of + or - 3.5 degrees and an elevation course width of + or - one-third of the selected elevation angle yield the best overall performance. Author

**N86-24677*#** Ohio State Univ., Columbus. ElectroScience Lab.

**A STUDY OF A COLLISION AVOIDANCE SYSTEM MOUNTED ON A CURVED GROUND PLANE Semiannual Report**

P. H. LAW, W. D. BURNSIDE, and R. G. ROJAS Mar. 1986 114 p refs

(Contract NSG-1498)

(NASA-CR-176771; NAS 1.26:176771; REPT-716199-8) Avail: NTIS HC A06/MF A01 CSCL 17G

Research conducted on a traffic advisory and collision avoidance system (TCAS 2) mounted on a curved ground plane is described. It is found that a curved finite ground plane can be used as a good simulation model for the fuselage of an aircraft but may not be good enough to model a whole aircraft due to the shadowing of the vertical stabilizer, wings, etc. The surface curvature of this curved disc significantly affects the monopulse characteristics in the azimuth plane but not as much in the elevation plane. These variations of the monopulse characteristics verify the need of a lookup table for the 64 azimuth beam positions. The best location of a TCAS 2 array on a Boeing 737 is to move it as far from the vertical stabilizer as possible. Author

**N86-24678*#** Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

**THE EVALUATION OF THE OSGLR ALGORITHM FOR RESTRUCTURABLE CONTROLS Final Report, Dec. 1985 - Apr. 1986**

W. F. BONNICE, E. WAGNER, S. R. HALL, and P. MOTYKA Mar. 1986 177 p refs

(Contract NAS1-17556)

(NASA-CR-178083; NAS 1.26:178083; CSDL-R-1849) Avail: NTIS HC A08/MF A01 CSCL 09B

The detection and isolation of commercial aircraft control surface and actuator failures using the orthogonal series generalized likelihood ratio (OSGLR) test was evaluated. The OSGLR algorithm was chosen as the most promising algorithm based on a preliminary evaluation of three failure detection and isolation (FDI) algorithms (the detection filter, the generalized likelihood ratio test, and the OSGLR test) and a survey of the literature. One difficulty of analytic FDI techniques and the OSGLR algorithm in particular is their sensitivity to modeling errors. Therefore, methods of improving the robustness of the algorithm were examined with the incorporation of age-weighting into the algorithm being the most effective approach, significantly reducing the sensitivity of the algorithm to modeling errors. The steady-state implementation of the algorithm based on a single cruise linear model was evaluated using a nonlinear simulation of a C-130 aircraft. A number of off-nominal no-failure flight conditions including maneuvers, nonzero flap deflections, different turbulence levels and steady winds were tested. Based on the no-failure decision functions produced by off-nominal flight conditions, the failure detection performance at the nominal flight condition was determined. The extension of the algorithm to a wider flight envelope by scheduling the linear models used by the algorithm on dynamic pressure and flap deflection was also considered. Since simply scheduling the linear models over the entire flight envelope is unlikely to be adequate, scheduling of the steady-state implentation of the algorithm was briefly investigated. Author

**N86-24679#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
**PRESSURE BASED SEPARATION IN THE UPPER AIRSPACE**
M. E. ESHELBY Feb. 1986 13 p
(CAR-8614; ISBN-0-947767-39-8) Avail: NTIS HC A02/MF A01

The vertical separation between aircraft above FL290 is 2000 ft which imposes a severe restriction on operations in the upper airspace. The possibility of reducing separations to 1000 ft has been discussed for many years but does not appear to be possible if current altimetry methods are used. The use of atmospheric pressure is proposed as the means of providing upper airspace separation. Current technology in altimetry would be adequate to enable separations based on pressure differentials to be used which allow a 50% increase in airspace utilization FL290 and FL350. The implementation cost of such a system is minimal. Author

**N86-24681#** Federal Aviation Agency, Atlantic City, N.J.
**COMPUTED CENTERLINE MLS (MICROWAVE LANDING SYSTEM) APPROACH DEMONSTRATION AT WASHINGTON NATIONAL AIRPORT**
J. H. REMER Oct. 1985 42 p refs
(AD-A163722; DOT/FAA/CT-TN85/63) Avail: NTIS HC A03/MF A01 CSCL 17G

This report describes the Computed Centerline Microwave Landing System (MLS) Approach Demonstration Project at the Washington National Airport. The purpose of this project was to demonstrate the capability of generating and flying a computed centerline approach for a nonstandard MLS siting. Specifically, the system which was developed enables final approaches to be made to runways which have azimuth units offset from the runway centerline. This system was successfully flight tested at the Federal Aviation Administration (FAA) Technical Center, Atlantic City Airport, NJ, and at the Washington National Airport. Runway 33 was used at Washington, with its MLS azimuth unit situated 275 feet to the right of the centerline. Conclusions derived from this project indicate that computed centerline approaches are indeed feasible. Precautions must be taken however, to properly tailor the course width. Site geometry and minima also impact system performance. In addition to the flight test data plots, the report contains system hardware and software design data. GRA

**N86-25334#** Massachusetts Inst. of Tech., Lexington.
**PILOT EVALUATION OF TCAS IN THE LONG RANGER HELICOPTER**
J. W. ANDREWS 3 Jun. 1986 30 p refs Sponsored by Massachusetts Inst. of Tech., Lexington. Prepared in cooperation with Federal Aviation Administration,Washington, D.C.
(Contract F19628-85-C-0002; DOT-FA77WAI-817)
(FAA/PM-85/30; ATC-136) Avail: NTIS HC A03/MF A01 CSCL 17G

A specially modified version of the Traffic Alert and Collision Avoidance System (TCAS) was installed in a Bell Long Ranger helicopter in order to investigate the feasibility of TCAS operation in rotorcraft. This installation employed TCAS air-to-air surveillance to provide automated traffic advisories that were displayed in the cockpit on a color cathode ray tube display. As part of this study, 12 subject pilots evaluated the utility of the installation through brief test flights in the vicinity of a major airport. Among the topics investigated were the rate of alarms, the computer logic for issuing advisories, the bearing accuracy, and the display symbology. Several recommendations for adapting TCAS to the rotorcraft environment resulted from the testing. Author

**N86-25335*#** Douglas Aircraft Co., Inc., Long Beach, Calif.
**GUIDANCE STUDIES FOR CURVED, DESCENDING APPROACHES USING THE MICROWAVE LANDING SYSTEM (MLS)**
J. B. FEATHER May 1986 90 p refs
(Contract NAS1-16202)
(NASA-CR-178030; NAS 1.26:178030) Avail: NTIS HC A05/MF A01 CSCL 17G

Results for the Microwave Landing System (MLS) guidance algorithm development conducted under the Advance Transport Operating System (ATOPS) Technology Studies (NAS1-16202) are documented. The study consisted of evaluating guidance law for vertical and lateral path control, as well as speed control, for approaches not possible with the present Instrument Landing System (ILS) equipment. Several specific approaches were simulated using the MD-80 aircraft simulation program, including curved, descending (segmented glide slope), and decelerating paths. Emphasis was placed on development of guidance algorithms specifically for approaches at Burbank, where proposed flight demonstrations are planned. Results of this simulation phase are suitable for use in future fixed base simulator evaluations employing actual hardware (autopilot and a performance management system). Author

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-33989**
**THE SOVIET FIGHTER - FOUR DECADES OF DEVELOPMENT**
R. BRAYBROOK Air International (ISSN 0306-5634), vol. 30, April 1986, p. 163-167, 199-203.

The development of the Soviet fighter from a single-role aircraft to a multirole aircraft is reviewed. Advances in designs, avionics, capabilities, and weapon systems are described. The initial designs of MiG fighter bombers and Sukhoi jet fighters are analyzed. The Sukhoi aircraft, Yak-25, was the first Soviet all-weather jet fighter and the MiG-25 Foxbat was the first in a series of multirole fighter interceptors. The development of an aircraft with short field performance, which was initiated by the Soviets, is discussed. The capabilities of MiG-20 Fulcrum which is a two-seat configuration and the Su-27 Flanker which is an aircraft with low-wing loading and a high thrust/weight ratio are studied. The capabilities and designs of Soviet aircraft are compared with their American counterparts. I.F.

**A86-33996**
**A METHOD FOR NUMERICAL ANALYSIS OF THE DYNAMICS OF A CONTROLLED ROTOR BLADE OF A HELICOPTER**
J. MANEROWSKI Journal of Technical Physics (ISSN 0324-8313), vol. 26, no. 1, 1985, p. 75-86. refs

A model for the numerical analysis of a controlled helicopter rotor blade in hover is presented. The finite element method in its displacement version is used, and numerical integration is performed using the Wilson-Newmark method. The rotor blade is treated as a deformable beam, its rigidity, inertia, and damping parameters varying along the blade. The influence of the cross-sectional rotational inertia on the form of the blade's elastic line is taken into account. An algorithm for the numerical analysis of the dynamics of a controlled blade is proposed, and examples of computational results are presented. C.D.

**A86-34156**

**A NOTE ON THE PREDICTION OF FLYING BOAT TAKE-OFF**

D. HOWE (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Feb. 1986, p. 49-52.

It is useful to have available simple prediction formulas for preliminary design work. In the case of landplane take-off such formulas exist, being expressed only in terms of a few major parameters. The flying boat situation is more complex due to the much greater and more variable total drag. By making appropriate assumptions an equivalent formula for flying boat take-off has been derived. Comparison of typical cases of the landplane and flying boat shows that whereas the take-off distance of the former is approximately inversely proportional to thrust/weight ratio to the power of 1.35, in the case of a flying boat it is inversely proportional to the square of thrust/weight ratio. Author

**A86-34196**

**EVOLVING 8000 PSI HYDRAULIC SYSTEMS**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 64-70.

The development of nonflammable hydraulic and lightweight high-pressure hydraulic systems nd components for military tactical aircraft is discussed. Based on preliminary Navy computer simulation studies, an 8000-psi hydraulic system T-2C trainer limited flight test program, full-scale A-7E evaluation, and full-scale Iron Bird simulation were conducted. Test results revealed normal and stable operation, low pressure fluctuations, and a 30-percent weight and 36-percent volume reduction. An Air-Force-developed nonflammable low-molecular-weight chlorotrifluoroethylene (CTFE) polymer possesses the desired viscosity characteristics, but has a density 2.2 times that of the current hydraulic fluids. Ongoing studies are being conducted to minimize horsepower/heat rejection, to stiffen the actuators, and to improve the CTFE fluid properties. R.R.

**A86-34475**

**FOKKER 50 - REPLACING A LEGEND**

D. LEARMOUNT and I. EPTON Flight International (ISSN 0015-3710), vol. 129, March 22, 1986, p. 28-33.

The design of the Fokker 50 is examined. Features designed to improve the comfort of the passengers are discussed. Alterations in the wing configuration including changes in the wing tips and ailerons are described. The fuselage structure is composed of metal adhesive bonded laminate sheets with stringers and has an increased number of doors and windows. The use of hydraulics in the undercarriage, braking, nosewheel steering systems, and flip sections is analyzed. The flying controls of the aircraft are mechanically and manually operated by a cable system. The improvements to the flight deck of the vehicle are studied. I.F.

**A86-34920#**

**DEVELOPMENT OF THE BO 105 LS**

A. HOHLEBEIN and G. POLZ (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) (CASI, Annual General Meeting, 32nd, Montreal, Canada, May 27, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Dec. 1985, p. 300-314.

The BO 105 LS is the newest version of the BO 105-family. It is specifically designed for operation at high altitudes and extreme temperature conditions as well as for improved single engine performance. This paper summarizes the technical main features and milestones of the BO 105 LS program. Performance and flight characteristics in the extreme regions of the extended flight envelope are discussed. The developmental flight test phase and the results of the numerous certification test campaigns are presented. The growth potential and versatile improvements of BO 105 LS due to the application of modern technology are discussed. Author

**A86-34924#**

**DESIGN OF THE CL-227 AIR VEHICLE**

D. J. PAISLEY (Canadair, Ltd., Montreal, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Dec. 1985, p. 346-359.

The CL-227 rotary wing VTOL RPV, designated 'Sentinel', is capable of carrying imaging payloads in the 30-kg mass range. Attention is presently given to the mechanical, structural, dynamic, aerodynamic, and control aspects of the Sentinel as they have developed in the course of full scale engineering development efforts. The configuration of Sentinel is that of a vertically-oriented axisymmetric body with a counterrotating rotor system mounted at its center. The rotors are powered by a gas turbine engine. Sentinel's hovering capability simplifies sensor requirements. The design is highly modular to facilitate maintenance in the course of a 500-hour design service life. A full authority autopilot and inertial reference unit are used. O.C.

**A86-35151#**

**FROM WIND TUNNEL TO LARGE AIRCRAFT [VOM WINDKANAL ZUM GROSSFLUGZEUG]**

R. HILBIG (Messerschitt-Boelkow-Blohm GmbH, Bremen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 22 p. In German.
(DGLR PAPER 85-088)

The development of a large aircraft from wind tunnel testing to large-scale construction is briefly discussed. The characteristic-tasks of the preparatory phase, the definitional phase, and the development phase are examined, and data for some important wind tunnels are presented. The determination of relevant aircraft parameters in wind tunnels is summarized. C.D.

**A86-35152#**

**DETAILS ON THE OPTIMIZATION OF CRUISING DRAG OF THE AIRBUS A320 [DETAILS ZUR OPTIMIERUNG DES REISEFLUGWIDERSTANDES DES AIRBUS A320]**

B. HAFTMANN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) and B. KIEKEBUSCH (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 38 p. In German.
(DGLR PAPER 85-089)

One of the objectives of the Airbus A320 is a six percent improvement in the drag standard as compared with the standard of the A310-200. Design studies conducted toward this end on the engine-pylon configuration and on the design of the tail assembly is reviewed. The influence of rearward position, pylon position, and nozzle length on drag is discussed, and an aerodynamic design concept for the tail assembly is presented and described. The influence of the design of the horizontal stabilizers and elevators on the total drag is also addressed. C.D.

**A86-35170#**

**COMPARATIVE INVESTIGATION OF OPTIMIZATION PROCEDURES IN AIRCRAFT PRELIMINARY DESIGN [VERGLEICHENDE UNTERSUCHUNG VON OPTIMIERUNGSVERFAHREN IM FLUGZEUGVORENTWURF]**

O. KRANZ (Berlin, Technische Universitaet, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 18 p. In German. DFG-supported research. refs
(DGLR PAPER 85-119)

This paper reports an analysis of the behavior of numerical optimization procedures in aircraft preliminary design. Basic aspects regarding the employment of optimization procedures are discussed, taking into account the error characteristics in different flight tasks, the wing aspect ratio as a function of maximum wing loading, and the derivatives of the target function in design space. The optimization procedures in aircaft preliminary design considered include tangent search methods and Lagrange methods. It is found that the tangent search methods are distinctly superior to the Lagrange methods, giving attention to computation time requirements, reliability, and user friendlines. G.R.

**A86-35176#**

**CONFIGURATION ASPECTS OF MODERN HIGH-PERFORMANCE AIRCRAFT [KONFIGURATIONSASPEKTE MODERNER HOCHLEISTUNGSFLUGZEUGE]**

G. KANNAMUELLER (Dornier GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 34 p. In German.
(DGLR PAPER 85-130)

The parameters which influence the design of the fighter aircraft JF 90 are discussed. Fighting ability, availability, and costs are related to each other in the context of a conflict model. The important design parameters are derived analytically along with the weapon systems design. These results are used to show what a fighter aircraft of the next generation may look like. Examples are used to demonstrate how the same fighter aircraft goals can be met in different ways by using different technologies. C.D.

**A86-35189#**

**OPTIMIZATION OF SEAPLANES [OPTIMIERUNG VON SEEFLUGZEUGEN]**

E. WILCZEK (Aachen, Rheinisch-Westfaelische technische Hochschule, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 34 p. In German.
(DGLR PAPER 85-170)

The optimization of seaplanes for marketing in coastal countries is discussed. The way in which the distribution of population in such countries affects the market for seaplanes is considered, and the market niches that could be taken by seaplanes in these countries are examined. The optimal design of seaplanes, including hydrodynamic and aerodynamic characteristics and the best selection of materials, is discussed. C.D.

**A86-35201**

**THE IMPACT OF ACCOMMODATING DEFECTS ON THE EFFICIENCY OF AIRCRAFT DESIGN**

E. M. PETRUSHKA and G. E. LAW (General Dynamics Corp., Fort Worth, TX) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 10 p. refs
(SAWE PAPER 1635)

The history of the evolution of damage tolerance criteria for metals as related to the B-58, F-111, and F-16 programs is reviewed, and the yet-to-be resolved damage tolerance issues for composite structures are discussed. In particular, the effect of defects on composite compression members is discussed in relation to defect location and size information provided by new automated nondestructive inspection techniques. It is pointed out that innovative ways of cost-effective three-dimensional reinforcement must be found so that the criticality of defects can be minimized directly by design. The importance of developing more durable and damage tolerant matrix materials is also emphasized. V.L.

**A86-35202**

**IMPACT OF ADVANCED MATERIALS ON AIRCRAFT DESIGN WEIGHTS - THE WEIGHT IMPROVEMENT FACTOR**

W. D. WISSEL (Airbus Industrie, Toulouse, France) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 24 p. refs
(SAWE PAPER 1636)

The improved metallic and nonmetallic materials currently used in the advanced aircraft are reviewed. A new generation of advanced materials is then examined with particular reference to their weight improvement potential and to the effect of the weight improvement factor on the overall design. The new materials examined include improved epoxy matrix systems providing both high strain and good hot/wet properties, advanced thermoplastics with high mechanical and temperature/solvent properties, and aluminum-lithium alloys. The effect of the new materials on the aircraft weight is analyzed with allowance for both fixed and variable weight components, and formulas for the weight improvement factor are derived. V.L.

**A86-35203*** Boeing Commercial Airplane Co., Seattle, Wash.

**APPLICATION OF DIGITAL/ELECTRIC SYSTEMS TO ADVANCED TECHNOLOGY AIRCRAFT**

A. R. BAILEY (Boeing Commercial Airplane Co., Seattle, WA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 13 p.
(Contract NAS1-17528)
(SAWE PAPER 1639)

Potential improvements in weight and performance of the digital/electric airplane of the 1990s are investigated, using data based on the Integrated Digital/Electric Airplane (IDEA) study, a nine-month investigation of integrated digital/electric concepts. A baseline configuration was compared to these IDEA configurations in terms of economic performance, fuel efficiency, and significant system and aircraft configuration characteristics. The 1990 baseline configuration represents a six to eight percent performance improvement over current technology; however, the IDEA airplane shows an additional three percent improvement in fuel burn performance. This improvement is due to a reduction of over 3000 pounds in systems weight alone. K.K.

**A86-35206**

**WING ASPECT RATIO OPTIMIZATION PROBLEMS FOR TRANSPORT TURBOJET AIRPLANES**

P. A. GILI and F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 26 p. refs
(SAWE PAPER 1660)

A calculation method, based on Breguet's formula for the distance range, for deriving the wing aspect ratio that will optimize the fuel consumption and the payload of the transport turbojet aircraft is described. The calculation of the load ratio and fuel wing consumption is discussed; the dependence of load ratio and fuel wing consumption on the wing aspect ratio, the cruising altitude, and the range and cruising lift coefficient is examined. The fuel consumption during climb is calculated using energetic evaluation. Diagrams and graphs of the data are provided. Examples displaying the applicability of this procedure to transport aircraft are presented. I.F.

**A86-35208**

**AN AIRFRAMER'S VIEW OF AN ELECTRIC FIGHTER**

J. R. MCKENZIE (General Dynamics Corp., St. Louis, MO) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 13 p. refs
(SAWE PAPER 1662)

The idea of an 'All-Electric' airplane which does not require on-board or ground-support generation of hydraulic or pneumatic power is quite attractive at first glance. Facets of this concept have received much study over the last few years (primarily in the commercial arena), and many benefits and pitfalls have been determined. The most likely scenario is development of a 'More-Electric' airplane that incorporates those features that provide benefits for a specific design. This paper surveys some of the key design issues and projects hypothetical airplane implementations. Author

**A86-35210**

**THE GRUMMAN X-29 TECHNOLOGY DEMONSTRATOR - TECHNOLOGY INTERPLAY AND WEIGHT EVOLUTION**

J. E. RAHA (Grumman Aerospace Corp., Bethpage, NY) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 22 p. refs
(SAWE PAPER 1665)

The history of Forward Swept Wing (FSW) design prior to the X-29A technology demonstrator is briefly recalled. The integration of the FSW with other elements of the demonstrator technology suite and the necessary interplay is described. A brief description or substantiation of the technology elements is included. The goals of the demonstrator program are reviewed and related to the design characteristics of the aircraft. Challenges facing the X-29A weight engineer are recounted, stressing weight-related development, which includes: (1) flight weight design of the FSW, (2) commonality

with other aircraft, (3) weight evolution and meeting weight goals, and (4) balance-critical aspects. The X-29A design is described from a weight and balance standpoint. Finally, future technologies are described and related to the existing technology suite.
Author

**A86-35219**
### THE MODEL 530MG - THE FORERUNNER TO THE ULTIMATE LIGHT-COMBAT HELICOPTER
R. V. MARCH (Hughes Helicopters, Inc., Mesa, AZ) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 44 p. refs
(SAWE PAPER 1677)

The Hughes Model 530MG Defender is a state-of-the-art rotorcraft, incorporating advances in performance as well as in cockpit and weaponization designs with minimal weight growth. In addition, an agile and effective flying platform with growth capability has been established, whose purpose is to provide broad mission flexibility for military services with variations in operational and environmental requirements around the world. It is shown that advances in performance as well as in the designs of an integrated cockpit and a modular, quick-change weapon system are present today and are expected to be standard for the U.S. Army's LHX advanced helicopter series. K.K.

**A86-35220**
### HIGHER HARMONIC CONTROL - VIBRATION REDUCTION FOR REDUCED WEIGHT
E. R. WOOD and B. P. GUPTA (Hughes Helicopters, Inc., Culver City, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 30 p. refs
(SAWE PAPER 1679)

Higher Harmonic Control (HHC) technology has been successfully applied to helicopter vibration reduction by exercising rotor blade pitch control at frequencies which are high harmonics of rotor rotation. The control motions are generated by three electrohydraulic actuators which are commanded by an airborne microprocessor. This processor receives vibration sensor measurements, estimates the helicopter's state using a Kalman filter type algorithm, and computes the optimal controls to reduce vibrations. A conventional helicopter equipped with this device would suffer a weight penalty of 0.75 percent gross weight, but new fly-by-wire controlled helicopters would, with HHC, experience a weight penalty that is essentially zero. For these aircraft, the only contributors to weight would be the miniaturized electronic circuit boards for the HHC system and the small additional weight of the HHC panel on the pilot's instrument console. K.K.

**A86-35223**
### STARSHIP I - A WEIGHT CONTROL CHALLENGE
H. L. FRISCH (Beech Aircraft Corp., Wichita, KS) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 17 p.
(SAWE PAPER 1682)

The Starship I utilizes many new state-of-the-art concepts in design, materials selection, and fabrication techniques for development of a next generation business aircraft. Composite materials comprise approximately 72 percent of the aircraft structural weight and are a major contribution to the success of the program. This presentation includes a description of the aircraft configuration, weight control philosophy, and computerized mass properties accounting system. Author

**A86-35224**
### WEIGHT CONTROL OF AIRCRAFT MODIFICATION PROJECTS
P. J. BUDDINE (Grumman Aerospace Corp., Bethpage, NY) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 11 p.
(SAWE PAPER 1683)

It is pointed out that the Mass Properties Control and Management Plans (MPCMP's), which are normally required by the government, are extremely useful. Modification programs are considered, taking into account the EF-111A program. This program was concerned with the modification of an F-111A to an EF-111A. In the event of an emergency, the F-111A Crew Module provides the primary means of escape from the aircraft. The location of the center of gravity of the crew module represents an extremely critical factor for a safe ejection and landing process, and the permissible weight is limited to 3200 pounds. Attention is given to some elementary principles which are essential for the design of a reasonable and effective mass properties control program. It is important that a weight control program is implemented early.
G.R.

**A86-35385*** Boeing Commercial Airplane Co., Seattle, Wash.
### ESTIMATION OF TRANSPORT AIRPLANE AERODYNAMICS USING MULTIPLE STEPWISE REGRESSION
D. A. KESKAR (Boeing Commercial Airplane Co., Seattle, WA), V. KLEIN (NASA, Langley Research Center; Joint Institute for Advancement of Flight Sciences, Hampton, VA), and J. G. BATTERSON (NASA, Langley Research Center, Hampton, VA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 927-932.

This paper presents an application of multiple stepwise regression to the flight test data of a typical transport airplane. The flight test data was carefully preprocessed to eliminate aliasing, time skews and high frequency noise. The data consisted both of basic certification maneuvers, such as wind-up-turns and maneuvers suitable for parameter estimation, such as responses to elevator pulses and doublets. It is shown that the results of multiple stepwise regression techniques compare favorably with the results obtained from maximum likelihood estimation. Finally, it is concluded that multiple stepwise regression could be a fast economical way to estimate transport airplane aerodynamics.
Author

**A86-35405**
### TRANSIENT MODEL OF A PNEUMATIC EJECTOR - APPLICATION TO THE SIMULATION OF AIRCRAFT BLEED AIR TEMPERATURE CONTROL SYSTEMS
R. ELANGOVAN and D. L. J. BRUSHWOOD (Boeing Military Airplane Co., Wichita, KS) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1187-1193. refs
(Contract F34601-82-C-2981)

A transient pneumatic ejector model suitable for use in simulation of aircraft environmental control systems is presented. The ejector model is formulated to accommodate modulation of both primary and secondary ejector flows using butterfly modulating valves. The two-state variable ejector model is employed in the simulation of an actual aircraft bleed air temperature control sytem, which utilizes ejector secondary air as the heat sink for a heat exchanger. The thermo-fluid system simulation equations and a qualitative description of control system operation are presented. Additionally, comparisons of the closed loop transient math model performance characteristics relative to actual ground and flight test results are presented. Author

**A86-35436**
### PILOT EXECUTIVE PROJECT - PILEX
R. W. WHITE and W. D. SMITH (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 87-91.
(SAE PAPER 851806)

The design and implementation of the Flight Status Monitor (FSM) concept are described. The pilot interfaces used for the altering, guidance, and feedback components of the FSM, and the supervisory logic provided by a knowledge-based expert system (KBES) are examined. The Pilot Executive project developed to study the FSM KBES requirements and to formulate a procedure for acquiring pilot knowledge of alert checklist integration techniques is analyzed. The three phases of the project which include concept demonstration, the integration of the system with an aircraft simulator for test and evaluation, and complete implementation of FSM KBES simulation and evaluation are discussed. I.F.

**A86-35438*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ADVANCED CONCEPTS TRANSPORT AIRCRAFT OF 1995**

S. L. CHAPPELL (NASA, Ames Research Center; Informatics General Corp., Moffett Field, CA) and G. A. SEXTON (Lockheed-Georgia Co., Marietta) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 103-108.
(SAE PAPER 851808)

The components of the Advanced Concepts Flight Simulation Facilities used to evaluate proposed human-machine interfaces are described. The facilities consist of: (1) an advanced concept flight station, which is a wide-body, composite airframe propelled by two turbo-fan engines; (2) an integrated air traffic control simulation; and (3) experimenter/observer stations. The flight controls and displays, and their operation are studied. The air traffic control provided in the simulation is examined. The control of the flight conditions and data collection by the experimenter are discussed. I.F.

**A86-35442**

**SIKORSKY AIRCRAFT CREW STATION TECHNOLOGY RESEARCH HELICOPTER**

L. STILES, JR. (United Technologies Corp., Sikorsky Aircraft Div., Strattford, CT) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 143-150.
(SAE PAPER 851780)

Sikorsky Aircraft has developed a new research helicopter dedicated to the study of crew station technology. A high visibility single seat cockpit has been added to an S-76 airframe just forward of the existing cockpit. The new cockpit is linked to the aircraft systems via a variable stability fly-by-wire flight control system and is equipped with various display media, including touch sensitive CRTs, a voice interactive system, head-up display, and a visually-coupled wide field of view helmet-mounted display system. The aircraft can be operated autonomously from the new crew station, with an independent safety pilot position retained at the original right pilot station. This aircraft will permit the evaluation of advanced control and display concepts in the agile S-76 air vehicle under a full range of flight conditions. Author

**A86-35455**

**EXTENDED RANGE OPERATION OF TWIN-ENGINE COMMERCIAL AIRPLANES**

R. W. TAYLOR (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 377-388.
(SAE PAPER 851959)

This paper discusses safety and reliability considerations that were examined in the development of new guidelines for commercial use of twin-engine airliners for extended range operations. The 767-200ER airplane is referred to extensively becausee it was the first twin to be approved for extended range operations under the new guidelines. The key technical issues involved are engine reliability and the ability of the propulsion and airplane systems to provide safe, sustained operation during the anticipated time period of the diversion after an inflight engine and/or system failure. Airline operational considerations for extended range operations with twins are reviewed, as well as the future impact on the traveling public and the airline industry brought about by the service introduction of new technology twins. Author

**A86-35520**

**THE FLYING SIMULATOR AND TECHNOLOGY CARRIER ATTAS FROM DFVLR [DER FLIEGENDE SIMULATOR UND TECHNOLOGIETRAEGER ATTAS DER DFVLR]**

D. HANKE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 7, 1st Quarter, 1986, p. 4-8. In German.

A new test aircraft called ATTAS (Advanced Technologies Testing Aircraft System), constructed as a modified VFW 614 and intended to replace the flying HFB 320 simulator, is described. The features and capabilities of this system include a cockpit with electric control and indicator systems, redundant computer system with optical data transmission system, extensive measurement and avionics systems, self-monitoring electrohydraulic control elements, and safety features. The aircraft's range of applications will include flight simulations, load minimization systems, avionics testing, traffic simulation, and pilot training. C.D.

**A86-35565*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**TILTROTOR - 'COPTER AND PLANE IN ONE**

M. BONDI (NASA, Ames Research Center, Moffett Field, CA) Mechanical Engineering (ISSN 0025-6501), vol. 108, April 1986, p. 52-59.

This paper is concerned with a most unusual aircraft, called the Tiltrotor XV-15, which combines the versatility of the helicopter with the characteristics of a conventional aircraft. Two large, three-bladed propellers are mounted at the tips of the wings. For takeoff, the propellers and their engines are rotated 90 degrees, and the XV-15 can climb vertically into the air as a helicopter. When the vehicle is off the ground, propellers and engines rotate forward, and the lift is transferred from the propellers to the wings. As a conventional aircraft, the Tiltrotor can cruise for more than two hours. Operating as a vertical-takeoff aircraft, the XV-15 can fly twice as fast as a helicopter and deliver payloads on half the fuel when traveling distances greater than 185 kilometers. The results of the first three years of flight-testing are discussed, taking into account the relationship of rotor vibrations and/or air turbulence to resonance of a section of the Tiltrotor's wing. G.R.

**A86-35603**

**CORRELATION OF STABILITY TEST RESULTS AND ANALYSIS FOR THE 1/5 SCALE V-22 AEROELASTIC MODEL**

D. POPELKA, J. BILGER (Bell Helicopter Textron, Fort Worth, TX), and M. SHEFFLER (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 17-31. refs

A semispan, 1/5-scale aeroelastic model of the V-22 tilt-rotor VTOL aircraft has been tested in the NASA-Langley Transonic Dynamics tunnel while undergoing modifications in such design parameters as hub design, blade bending stiffness, wing spar stiffness, rotor pitch-flap coupling, and pylon downstop configuration. Compressibility effects were investigated by tests in both air and freon; aerostatic stability data were obtained for a wide range of airspeeds, rotor speeds, and conversion angles. These data were correlated with aeroelastic stability analysis programs in order to validate the analytical tools being used in the V-22's full scale design process. O.C.

**A86-35605**

**EFFECTS OF ANALYTICAL MODELING ASSUMPTIONS ON THE PREDICTED STABILITY OF A MODEL HINGELESS ROTOR**

R. SOPHER and S. J. CASSARINO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 85-99. refs

The ability to predict flap lag torsion stability is presently evaluated for an aeroelastic stability analysis that is applied to test results for a stiff, inplane hingeless rotor model in hover, with a view to identifying the variables to which the analysis is sensitive. Results are obtained for six different model configurations; a good-to-fair ability is noted in the prediction of edgewise mode stability variations with pitch angle, pitch flexure stiffness, preconing, and droop. High sensitivities to equilibrium deflections, torsional representations, and aerodynamic assumptions are found. O.C.

**A86-35607**

### AIRCRAFT LIGHTING SYSTEMS

J. F. VERNEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 111-120.

Current aircraft lighting systems design involves both consideration of unaided eye viewing as well as compatibility with night vision goggles (NVG). The prospective lighting systems engineer must have knowledge of photometrics and radiometrics as well as an understanding of the NVG's electro-optical characteristics. In checking a preliminary design concept, laboratory mock-ups must be performed using NVGs in conjunction with empirical test methods. Quantitative parameters are then established which allow preliminary specifications to be generated. A flight-worthy mock-up should be built to provide dynamic verification of design concept. Applying this basic process to the UH-60A night vision lighting development program has resulted in some important findings. In particular the use of red light for warning indicators is permissible if modified to incorporate an infrared blocking filter. Also some general guidelines for infrared exterior lighting and interior blue-green integral lighting have emerged. Author

**A86-35613**

### THE HEALTH AND USAGE MONITORING OF HELICOPTER SYSTEMS - THE NEXT GENERATION

J. D. ROE and D. G. ASTRIDGE (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 175-187. refs

The Helicopter Airworthiness Requirements Board's review of helicopter airworthiness made recommendations to which Health and Usage Monitoring (HUM) systems may be relevant; these onboard maintenance processor systems encompass sensors, interfaces, data links, processors, and output devices. HUMs undertake vibration analyses, debris monitoring for transmissions, power assurance checking, low cycle fatigue and thermal creep monitoring for engines, and torque and strain monitoring for complete transmission/rotor systems. Attention is given to HUM sensors and algorithms recently developed and flight tested, as well as to the effect of these systems on maintenance policies. O.C.

**A86-35620**

### HELICOPTER CABIN NOISE - ACTUAL VS. STATISTICAL ENERGY PREDICTIONS

C. A. YOERKIE and P. J. GINTOLI (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 277-287.

The Statistical Energy Analysis (SEA) technique's predictions are subjected to comprehensive comparisons with measured aircraft cabin noise data obtained for an S-76 helicopter. SEA modeling is found to provide a complete description of the energy flow within the structure with a relatively small number of degrees-of-freedom, while retaining the high frequency prediction capability required for acoustics. The vibration trends for such structural elements as panels and frames are found to be in good agreement with predictions; cabin sound pressure level predictions also agree with measurements. SEA is also noted to provide insight into the flow of energy through the structure. O.C.

**A86-35624**

### FLIGHT INVESTIGATION OF BELL MODEL 206 RING FIN

H. K. HARR, P. J. HOLLIFIELD (Bell Helicopter Textron, Fort Worth, TX), and R. P. SMITH (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 327-337. refs

Flight testing has been conducted for a Model 206 helicopter whose conventional vertical fin was removed and replaced by several 'ring fin' configurations; these furnish a protective annulus around the tail rotor in the plane of rotation. Attention was given to the effects of such design variables as ring and dorsal fin incidence and areas. The handling quality results obtained indicate the feasibility of the ring fin as a tail rotor protection device. O.C.

**A86-35627**

### APPLICATION OF HELICOPTER AIR-TO-AIR COMBAT TEST (AACT) DATA TO CURRENT LHX CONCERNS

F. J. EBERT and N. D. LAPPOS (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 367-385. refs

Extensive air-to-air combat tests have been conducted by U.S. Army, Navy and industry teams with instrumented AH-1S, OH-58, AUH-76, UH-60A, and BK-117 helicopters; the agressive maneuvers undertaken comprise elements of the projected LHX light combat helicopter's nap-of-the-earth mission. On the basis of the data thus obtained, pertinent combat issues are presently explored, and previously employed modeling tecniques are validated. Attention is given to maneuvering concepts, rotor thrust, static structures, excess power, rotating structural loads, transient load factors, and available turn rates. O.C.

**A86-35628*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### FREE-TIP-ROTOR WIND-TUNNEL TEST RESULTS

R. H. STROUB, L. A. YOUNG (NASA, Ames Research Center, Moffett Field, CA), C. KEYS, and M. CAWTHORNE (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 387-411. refs

Seven controller mechanisms and several tip geometries were proposed and evaluated in the course of a free tip rotor development program which integrated those components into a model rotor system for wind tunnel testing. After a rigid whirl test was run to determine controller mechanism performance and structural integrity, a second whirl test was performed with a model rotor incorporating a selected controller design and a selected tip platform to determine the transient behavior of the tips in response to aerodynamic excitation. The results obtained demonstrate that a swept, tapered tip with a tension-torsion strap controller furnished satisfactory mechanical operation, achieved the specified output torque, possessed a low spring rate, and had fast and stable response to excitation. O.C.

**A86-35629**

### THE DESIGN OF THE EH101 FOR SAFETY AND PERFORMANCE

R. I. CASE and K. J. ANDREWS (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 413-422.

A development history and a performance evaluation are presented for the Anglo-Italian EH101 military helicopter. Attention is given to those aspects of structural design in the EH101 that have been optimized for flight safety, damage tolerance and crashworthiness. The extensive use of primary structure composites introduces a substantial degree of integrity for a high frequency fatigue environment, in virtue of their slow crack propagation and fail-safe characteristics. Health and usage monitoring techniques are applied, as well as a three-engine installation with highly redundant systems. O.C.

**A86-35630*** Boeing Vertol Co., Philadelphia, Pa.

### DESIGN ASPECTS OF THE XV-15 ADVANCED TECHNOLOGY BLADE PROGRAM

K. E. SMITH, H. R. ALEXANDER (Boeing Vertol Co., Philadelphia, PA), and M. D. MAISEL (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 423-433.

The paper discusses the design of a tiltrotor blade for application to the XV-15 research demonstration aircraft. The design features 43 deg nonlinear twist and nonuniform tapered planform. The structure is composite with extensive use of graphite in the primary structure. Instrumentation and wiring is encapsulated in the composite structure during the cure cycle. The tip shell is removable, providing access to the tracking and balance weights. This feature provides research facility of alternate tip configurations. The cuff is similarly removable. The graphite epoxy system used is high strain American Cyanamid's Celion 6000ST/Cycom 950. This is the first application of this material in rotor blades. Author

**A86-35631**

### X-WING POTENTIAL FOR NAVY APPLICATIONS

A. W. LINDEN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and J. C. BIGGERS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 435-450.

An evaluation is made of the performance potential offered by X-wing configuration VTOL aircraft in typical U.S. Navy missions. X-wing aircraft function as helicopters at takeoff and hover, but turn the X-planform rotor into a fixed wing platform for high speed forward flight. A development history is also given for successive refinements of the X-wing configuration in wind tunnel models and experimental aircraft. Attention is given to such performance attributes as the power required in hover and in cruise, hover control power, and empty and payload weight fractions; such Navy missions as fleet defense and combat search and rescue are defined, and the configuration of a technology demonstration aircraft is projected. O.C.

**A86-35632**

### INFLUENCES OF TWO LANDING GEAR DESIGNS ON HELICOPTER CRASHWORTHINESS AND WEIGHTS

J. K. SEN, M. W. VOTAW (Hughes Helicopters, Inc., Culver City, CA), and G. R. DOWNER (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 451-461. (Contract DAAK51-83-C-0039)

The systems approach to crashworthiness is applied to a study of two landing gear designs to evaluate their influences on helicopter weights for survivable crash-impact conditions. Both landing gear designs share a trailing arm configuration; however, one is coupled and the other uncoupled. The coupled design requires that both main landing gear struts stroke and absorb energy together during high roll impacts. The designs and their influences on the crushing behavior of the landing gear, fuselage and crew seat, and the responses of the occupants are evaluated with program KRASH. The results of the analysis are used to develop weight trend curves for the two designs as a function of the impact parameters (impact velocity, roll angle and pitch angle) and the probability of occurrence of survivable helicopter accidents. Author

**A86-35635*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AERODYNAMIC PERFORMANCE OF A 27-PERCENT-SCALE AH-64 WIND-TUNNEL MODEL WITH BASELINE/ADVANCED ROTOR BLADES

H. L. KELLEY and J. C. WILSON (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 491-499. refs

Performance of a 27-percent scale model of an advanced rotor designed for the AH-64 helicopter was measured in hover and at forward speeds of 50 to 130 knots. A baseline rotor, modeled after the current AH-64 rotor, was also tested to provide data for comparison. The investigation was conducted to validate procedures used at Langley to design rotors with increased performance potential and to provide a database for evaluation of current and future rotor systems. Both rotors were operated at full-scale tip speeds. Rotor thrust, forward speed, and ground height were varied for each rotor. Author

**A86-35637**

### A SKIN-STRINGER DESIGN FOR A CRASHWORTHY COMPOSITE FUSELAGE FOR THE HUGHES 500E HELICOPTER

J. K. SEN and M. W. VOTAW (Hughes Helicopters, Inc., Culver City, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 547-558. refs

The design of the lower fuselage of the Hughes 500E helicopter is part of the Composite Fuselage program of Hughes Helicopters, Inc. The objectives of the program are to design, fabricate, test and fly a composite fuselage which will meet the vertical impact requirements of MIL-STD-1290 with a minimum of 22 percent savings in weight over the metal design. The design approach used on the crashworthy composite lower fuselage assembly is a simple skin-stringer design without honeycomb structural elements, but which is similar to the existing metal design. The decision to use this approach is a result of trade-off studies, design development tests, and the requirement of mating existing support components, such as the landing gear, to the composite fuselage. The design has been evaluated through impact tests and KRASH analyses. The results of the tests show that the crashworthy objectives can be met with 26 percent savings in weight and 39 percent fewer parts. Author

**A86-35638**

### EFFECTS OF VARIATIONS IN CRASHWORTHINESS CRITERIA ON SIKORSKY S-75 ACAP LANDING GEAR WEIGHTS

B. L. LEE and S. P. GARBO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 559-571. refs

(Contract DAAK51-83-C-0016)

Attention is given to the results of a study evaluating the effects of variations in airworthiness design criteria on the weight of landing gear and backup structures, using the S-75 helicopter's Advanced Composite Airframe Program design as a baseline. Such critical design parameters as sink speed, roll angles and pitch angles were separately varied in order to assess their individual effect on landing gear system loads and weights. Parametric studies of the various combinations of maximum sink speed, roll, and pitch crash conditions indicate 24-32 percent required increases in landing gear system weights. Crashworthiness criteria for future U.S. Army helicopter designs are thereby quantified. O.C.

**A86-35639**
**PRELIMINARY ESTIMATE OF FATIGUE LIFE FOR DYNAMIC COMPONENTS OF A NEW HELICOPTER**
K. B. AMER, D. H. MANCIL, and J. R. NEFF (Hughes Helicopters, Inc., Culver City, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 573-582.

Attention is given to a procedure for the sizing of major helicopter dynamic components for satisfactory fatigue life during preliminary design. The procedure establishes a limited number of representative flight maneuvers and a criterion for the ratio of load in each representative maneuver to the fatigue strength; it then predicts the load at each of the maneuvers and sizes the dynamic component to meet the payload-ratio criteria. The criteria that must be met in order to achieve a 4500-hr service life are presented. O.C.

**A86-35642**
**SURVEY OF CRASHWORTHINESS ACHIEVEMENTS ON AEROSPATIALE HELICOPTERS**
J. MENS (Aerospatiale, Division Helicopteres, Paris, France) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 595-608. refs

Attention is given to proprietary helicopter crash protection techniques that have been under development since 1976 for cabin seating, fuel systems, and landing gear units; these crashworthiness-enhancing measures have entered mass production in such aircraft as the Super Puma and Dauphin helicopters. The theoretical studies on which development of these techniques was predicated consisted of parametric analyses of structural element resistance to crash damage. Attention is given to the resulting airframe structures, crashworthy seats, high energy absorption landing gear, and crashworthy fuel tanks and their interconnections. O.C.

**A86-35648**
**COMBINING ANALYSIS AND TEST FOR ROTOR BLADE DEVELOPMENT**
R. JONES and N. GIANSANTE (Kaman Aerospace Corp., Bloomfield, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 639-645. refs

Attention is given to a method combining test results with analyses in order to enhance predictive capability in rotor blade development. This method has been applied to the SH-2F Composite Main Rotor Blade. Nonlinear regression equations for blade bending moments are developed as a function of blade ballast configuration, using data obtained from an aeroelastic loads program. These equations are subsequently modified on the basis of simulated test data obtained from the Rotorcraft Flight Simulation Computer Program. O.C.

**A86-35649**
**DEVELOPMENT OF A COMPOSITE TAIL ROTOR BLADE FOR THE MH-53E**
A. J. LAPATI and A. E. THOMPSON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 647-660.

MH-53E airborne mine countermeasures helicopter requirements for improved performance, unlimited replacement time, and damage tolerance in tail rotor blades have been addressed by a cocured composite blade design. Attention is given to the methods and results of the new blade's qualification tests. Full scale fatigue testing in specially designed facilities has demonstrated the required strength and damage tolerance characteristics; the critical fatigue modes revealed at the root, midspan and tip locations by crack initiation tests have been propagated to determine damage tolerance. Preflight whirl tests also yielded stability, performance, acoustic, and endurance data. O.C.

**A86-35652**
**DESCRIPTION AND INITIAL FLIGHT EXPERIMENTS - BOEING ARTI TEST BED**
C. HUTCHINSON, E. BANEY-BARTON, and R. GRADLE (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 679-690.

A test program has been conducted to examine the automated cockpit systems required by the LHX light combat helicopter, including avionics, visionics, etc, to accomplish its missions under single pilot control. A modified Agusta 109A helicopter is the Advanced Rotorcraft Technology Integration testbed employed in these development tests. Electronic scene generation has been used to validate simulator/aircraft correlation. It is established that, in order to fly nap-of-the-earth missions in adverse nocturnal weather conditions, some type of electronic scene generation will be required. O.C.

**A86-35653*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**RSRA FLIGHT DEVELOPMENT TEST IN THE AIRPLANE CONFIGURATION**
R. E. ERICKSON, R. M. KUFELD, J. L. CROSS, and C. W. ACREE (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 198 , p. 691-704.

The Rotor Systems Research Aircraft (RSRA) was flown in the airplane configuration. Eleven successful flights were made from May 8 to October 3, 1984. The takeoff and landing method was demonstrated and the resultant parameters were obtained. Control power data were obtained. In addition, main rotor hub drag, airplane configuration acoustics data, and aircraft stability data were obtained. Hub drag, acoustics, and stability will be separately reported in more detail. The tail rotor was installed for all tests. Author

**A86-35654**
**VSTOL AIRCRAFT ICE PROTECTION DESIGN CONSIDERATIONS**
A. A. PETERSON (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 714-723. refs

Ice Protection Systems for VSTOL aircraft such as the Bell-Boeing V-22 OSPREY Tilt-Rotor must operate in both the helicopter and the fixed-wing aircraft flight modes. This paper presents the design approaches selected and illustrates the control concepts for activating each of the ice protection subsystems. Author

**A86-35661**
**TILT ROTOR CRASHWORTHINESS**
J. D. CRONKHITE (Bell Helicopter Textron, Fort Worth, TX) and A. E. TANNER (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 801-816. refs

Large mass relief, rollover stability, reduced pitch and roll attitude on impact, and flotation stability, are among the advantages in crashworthiness design that tilt-rotor aircraft possess over conventional helicopters. The results of a crashworthiness design feature tradeoff study conducted for the V-22 'Osprey' tilt-rotor aircraft are presented, with attention to the weight and cost effectiveness of various crashworthiness levels. The V-22 design also employs a systems approach to the provisions of occupant crash protection; the highly crashworthy composite structure incorporates a dual purpose energy absorbing underfloor, and allows controlled failure of the wings to prevent fuselage collapse. O.C.

**A86-35662**

**THE DESIGN AND DEVELOPMENT OF NEW CRASHWORTHY SEATS FOR NAVY HELICOPTERS**

B. L. CARNELL (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 817-826. refs

U.S. Navy funded programs to design and develop new crashworthy crew seats for the SH-3D, G, and H anti-submarine and the CH-53A/D troop/cargo helicopters are described. The specifications for the seats include the peculiar requirements of installing stroking, load-attenuating seats in the confines of the cockpit and the need to match the loads on the seat support structures to the strengths of those structures. The seats, designed by Simula, Inc., Tempe, AZ, use variable load energy attenuators to accommodate a wide range of occupant weights. The seats for the CH-53A/D helicopters also provide armor protection for the crewmembers. Comprehensive qualification tests including operational, environmental, static, and dynamic tests are described. The improvements in crash safety are related to those of the U.S. Army BLACK HAWK helicopter. Author

**A86-35663**

**THE HUGHES INTEGRATED APPROACH TO HELICOPTER CRASHWORTHINESS PAST, PRESENT, AND FUTURE**

A. H. LOGAN and M. W. VOTAW (Hughes Helicopters, Inc., Culver City, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 827-835. refs

Military requirements for improved performance and crashworthiness have necessitated changes in the design of helicopters. Future helicopters will be designed around a system of energy absorbing components that are sized to maximize performance and survivability while minimizing weight. Designs made from advanced composite materials promise higher performance levels by taking advantage of the materials' specific strength and stiffness characteristics. The effects on crashworthiness of these emerging composite designs have not been fully investigated; however, the data generated to-date, from static and dynamic crush tests, suggest that the crashworthiness levels of present metal structures can be matched or exceeded through innovative composite designs. The future generation of crashworthy helicopters will draw on these and other technological advances as well as the experience from previous successful designs. Author

**A86-35664**

**ARMY HELICOPTER CRASHWORTHINESS - LOADING THE BATTLEFIELD DICE IN OUR FAVOR**

K. F. SMITH (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 837-849. refs

This paper presents aspects of Army helicopter crashworthiness design with emphasis on the systems approach to energy absorption. Past successes, such as the crashworthy fuel system, are reviewed and some of the more recent findings in energy absorbing seats, composite subfloors and landing gear designs are presented. Finally, a review of proposed changes to the Army crashworthy crewseat specification (MIL-S-58095) and the aircraft crashworthiness military standard (MIL-STD-1290) are discussed. Author

**A86-35665**

**CRASHWORTHY DESIGN OF ROTORCRAFT - A BASIC RESEARCH APPROACH**

S. HANAGUD, J. I. CRAIG, D. SCHRAGE, and P. SRIRAM (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 851-866. refs

(Contract DAAG29-82-K-0094)

Crashworthy design of a rotorcraft constitutes a very important branch of the general field of rotorcraft design. A successful crashworthy design leads to many potential benefits. However, many different disciplines are involved and a number of constraints must be met when the subject of rotorcraft crashworthy design is analyzed. Some of the significant constraints involve the considerations of weight, cost, and performance. Potential weight savings that can be realized using composite materials when offset by additional material required for energy absorption or to maintain structural integrity offers the promise of extending the survivable crash envelope for future rotorcraft. A very brief discussion of the field, some potential problems in different disciplines concerning the crashworthy design of composite rotorcraft, and some suggestions, including basic research approaches, are presented in this paper. Author

**A86-35668*#** Texas A&M Univ., College Station.

**PERFORMANCE DEGRADATION OF HELICOPTERS DUE TO ICING - A REVIEW**

K. D. KORKAN (Texas A & M University, College Station), L. DADONE (Boeing Vertol Co., Philadelphia, PA), and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) AHS, Annual Forum and Technology Display, 41st, Fort Worth, TX, May 15-17, 1985, Paper. 22 p. refs

(Contract NAG3-242)

Methodology developed to predict the performance degradation of rotating systems in natural icing conditions is described and discussed. Theoretical studies of the increments performance degradation due to icing involving the propeller, helicopter in hover and forward flight, and XV-15 propulsion modes are summarized. Related experimental studies on the NACA 0012 airfoil and model helicopter with/without generic ice shapes are reviewed. The results of these experimental and theoretical studies are used to suggest refinements to current methodology. C.D.

**A86-35977**

**A RELIABILITY CONCEPT IN STRUCTURAL OPTIMIZATION OF FLIGHT VEHICLES [OB ODNOI KONTSEPTSII NADEZHNOSTI PRI OPTIMIZATSII KONSTRUKTSII LETATEL'NYKH APPARATOV]**

S. V. ARINCHEV and V. V. BYSTROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 7-12. In Russian. refs

A multidimensional quantile of the parameters of a system of a given order is adopted as a reliability function of the system. A lower bound on the multidimensional quantile is obtained in terms of one-dimensional quantiles, and a relationship is established between the lower bound and the known upper bound of multidimensional probability. The possibility of using this estimate as an optimization function in flight vehicle design is illustrated through numerical modeling. V.L.

**A86-35978**

**THE OPTIMAL TAKE-OFF RUN OF AN AIRCRAFT ON AN UNPAVED SURFACE [OPTIMAL'NYI RAZBEG SAMOLETA PO GRUNTU]**

A. A. BADIAGIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 12-16. In Russian. refs

The problem of optimizing the take-off run of an aircraft is investigated analytically. It is shown that the most favorable lift coefficient of a wing during the take-off run depends on the rolling resistance coefficient of the wheels. It is further shown that for a soft unpaved surface there exists an optimal-in-the-limit take-off run with fixed and relatively large angles of attack. V.L.

**A86-35981**
**THE EFFECT OF THE ADMISSIBLE CENTERING MISALIGNMENT OF A TRANSPORT AIRCRAFT ON ITS MASS [VLIIANIE DOPUSTIMOGO RAZBEGA TSENTROVOK TRANSPORTNOGO SAMOLETA NA EGO MASSU]**

V. P. GOGOLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 24-28. In Russian.

A solution is presented for the problem of determining changes in the mass of an aircraft resulting from a centering misalignment occurring during service. The solution is based on the concept of aircraft mass increase coefficients. Computational formulas are presented, and their use is illustrated by an example. V.L.

**A86-36333**
**SUKHOI FROGFOOT**

R. BRAYBROOK Air International (ISSN 0306-5634), vol. 30, May 1986, p. 222-226.

The SU-25 Soviet fighter is configured for counterinsurgency missions, such as is evident in its Afghanistan applications. Modeled after the USAF A-X design of the late 1960s, the SU-25 has STOL capabilities similar to the A-10 aircraft, and is a large, very maneuverable jet. Differences include a slightly higher speed, smaller overall dimensions, more static thrust and a flat thrust curve. Its relatively short intake ducts are elliptical, which is thought to minimize flow distortions. The pilot relies on three rear-view mirrors and possibly a HUD display for extending the visual field. The aircraft has pylons for exterior weapons stores and fuel tanks, and is thought to be ultimately envisioned as a close support, local air superiority fighter for Central Europe. M.S.K.

**A86-36334**
**STEALTH COMES STEALTHILY**

J. JONES Air International (ISSN 0306-5634), vol. 30, May 1986, p. 227-229, 258, 259.

Stealth aircraft, actually a series of military aircraft that is part of the Covert Survivable In-Weather Reconnaissance Strike program, are asserted to have reached an initial operational stage with the F-19A fighter/reconnaissance aircraft. The design goals, defined after tests in the early 1970s, included a very low radar cross section, radar absorbent airframe and internal structure, minimized engine noise levels, cooled engine exhaust to reduce IR signature and inclusion of advanced ECM equipment. The fuselage is blended into the planform, as with the Orbiter, and the anhedral of the wing increases from root to tip. Air intakes are side-by-side above the wing and partially shielded by small winglets. The F-19A is thought to have a cruise speed of Mach 2.0 and to be made mainly of Fiberloy, i.e., boron fiber reinforced plastic. The pure metal fraction of the aircraft is under 5 percent and is mostly in the engine. The leading edges of the wings, fins and canards and the outer engine skins are made of nonreflecting CFRP material to reduce thermal and radar signatures. Much of the technology is being incorporated into the B-2B bomber prototype, which may be a flying wing for low altitude, subsonic penetration bombing missions. M.S.K.

**A86-36818**
**PACIFIC AEROSYSTEMS CONTINUES DEVELOPMENT OF HERON 26 VEHICLE**

Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 63, 64, 66.

The current stage of development of the Heron 26 RPV includes an on-board FLIR system and a television platform. Although eliminated from competition for a Navy procurement of the vehicles, consideration is being given to supplying the Heron avionics and ground stations for use in the Mirach-20 system, which has sales overseas. An innovative feature of the Heron is the navigation system, the Mizar, which uses Omega VLF as a primary positioning link at present and will access the GPS when it is operational. Updates can also be issued to the aircraft from the ground station through high speed burst links. The autonomy of the system permits the Heron to fly a predetermined course and return for pick-up, all automatically. The course accuracy is a 400 m circular error probability (CEP) with Omega and 50 m CEP with GPS. The Heron has a composite airframe, twin-boom tails, a pusher propeller, an overall length of 12.9 ft and a height of 3.8 ft. Flight performance is an 11,500 ft altitude normal, 20,000 ft with modifications, and cruise speed of 85 kt for 5 hr. M.S.K.

**A86-36819**
**DEVELOPMENTAL SCIENCES PREPARES SKYEYE FOR ARMY COMPETITION**

Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 68, 69, 72 (3 ff.).

The Skyeye R4E-40 mini-RPV is a 520 lb. maximum weight entry into the Army intelligence and EW unmanned aerial vehicle competition. The new generation of RPVs is targeted for uses as decoys and for reconnaissance and damage assessment roles. The RPV has already carried a 90 lb. FLIR system for 9.3 hr at 3000 ft altitude and a 70 kt loiter speed. The vehicle is capable of a 500 fpm climb speed to 10,000 ft and a 130 kt top speed. Besides the FLIR cameras, the Skyeye can carry IR line scanners, a 35 mm panoramic scanner and a meteorological package. The airframe is an all-composite structure with a 13.8 ft length and a 17.5 ft wingspan. A crew of six is required for operations, linked to the Skyeye by 1-2 GHz telemetry. Flight is controlled manually, by an autopilot or is preprogrammed for reference to up to 25 waypoints to satisfy desired heading, altitude, airspeed and sensor commands. The autonomous mode includes the capacity for loiter if the base link is broken, followed by a return to the last known base position after a preset time interval. Previous projects the manufacturer was involved in are summarized to partially describe the climate for producing RPVs during the period of low demand since the end of the Vietnam War. M.S.K.

**A86-36820**
**ARMY COMPLETING DEVELOPMENT TESTS FOR LOCKHEED AQUILA RPV SYSTEM**

Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 85-87, 89.

The Aquila RPV is the lead contender in an Army effort to procure an unmanned, miniaturized airborne reconnaissance and laser designating system which is mobile and survivable on a modern battlefield. The Kevlar/epoxy vehicle is 7 ft long, has a wingspan under 13 ft, weighs less than 265 lb. with payload, and can be fitted with an INS for autonomous navigation past preprogrammed waypoints. The maximum of 60 lb. payloads can include a television camera, the laser designator and stabilized optics, and a FLIR for nighttime operations. An antijam capability has been developed for Aquila, which is carried on an Army truck and is caught by a net following flight. The ground crew numbers three personnel. Preliminary tests to prove the production-worthiness of the vehicle have resullted in performances that meet or exceed the requirements, including over 20 min. unattended flight, simultaneous control of two vehicles in flight by the ground station, and 100 percent success at designating moving or stationary targets with the laser apparatus. A 1990 operational status is projected for squadrons of the million dollar Aquilas. M.S.K.

**A86-36821**
**U. S. ARMY PLANS TO EVALUATE CANADAIR CL-227 SENTINEL**

Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 103, 105.

The CL-227 RPV is under development for service in short- to medium-range operations at the brigade level. The 10-ft wingspan CL-227 consists of two spherical modules, powerplant at the bottom and payload at the top, and two 3-bladed counterrotating propellers. The blades have Kevlar skins surrounding foam cores. The vehicle is designed to fly for 3-4 hr, carry a 60-100 lb. payload, travel at up to 70 kt or hover, and climb up to 10,000 ft. The powerplant, furnishing 50 shp and functioning at 100 krpm stepped down to 1 krpm, exhausts upward to mix the exhaust with the downwash and thus to lower the IR signature. Directional changes and flight stability are controlled through low order differential alterations in the propeller speeds. The vehicle is either flown by a joystick handled by the ground crew or can be programmed to take-off and automatically follow waypoints. Landing is automatic once the vehicle is positioned over a designated landing spot. The CL-227 may be used for reconnaissance, decoy, communications relay or ECM applications. M.S.K.

**A86-36822**
**NORTHROP DELIVERS RPVS TO NAVY TO AID IN DEVELOPMENT PROPOSAL**
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 123, 125, 127.

Deliveries have begun of the BQM-74C target drone reconfigured to serve in reconnaissance applications. The modifications include a nose with a fixed, unstabilized video camera for real-time image transmissions and a 10:1 zoom capability. The camera is equipped with a video cassette for storage when out of telemetry link. A 240-400 n.mi. range is provided, along with flight altitudes of 30-30,000 ft and speeds of 250-500 kt. Video telemetry can be broadcast from 50-70 n.mi., depending on the flight altitude, and the command and control range is 35-50 n.mi. The entire flight of the RPV can be conrolled by an on-board autopilot which can handle speeds, altitudes and maneuvers according to a preprogrammed sequence. The video telemetry is linked to video processors with full storage and playback, real-time and stop-frame capabilities. A larger version of the vehicle is under development to extend the range of use for decoy, reconnaissance, electronic signal intercept, weather data gathering and jamming. M.S.K.

**A86-36946**
**SIMULATION OF AIRCRAFT COMPONENTS FOR TRAINING PURPOSES**
D. HOWE (Burtek, Inc., Tulsa, OK) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 51-59.
(SAE PAPER 851965)

A simulation system applied to a primary and secondary flight controls trainer, using nonaircraft commercial parts to teach maintenance and rigging, is presented. Simulation techniques include the use of reduced pressure hydraulics, substitution of electrical drivers and generation of synthetic signals to test equipment. Realism, system functionality and electrical and mechanical interfaces were not compromised, while benefits such as cost savings, schedule improvement and greater safety were derived. It is concluded that all the objectives of using simulated, rather than actual aircraft, components were achieved. K.K.

**A86-37064*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
**SUMMARY OF RESULTS OF NASA F-15 FLIGHT RESEARCH PROGRAM**
F. W. BURCHAM, JR., G. A. TRIPPENSEE, D. F. FISHER, and T. W. PUTNAM (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 32 p. NASA-supported research. refs
(AIAA PAPER 86-9761)

NASA conducted a multidisciplinary flight research program on the F-15 airplane. The program began in 1976 when two preproduction airplanes were obtained from the U.S. Air Force. Major projects involved stability and control, handling qualities, propulsion, aerodynamics, propulsion controls, and integrated propulsion-flight controls. Several government agencies and aerospace contractors were involved. In excess of 330 flights were flown, and over 85 papers and reports were published. This document describes the overall program, the projects, and the key results. The F-15 was demonstrated to be an excellent flight research vehicle, producing high-quality results. Author

**A86-37081#**
**FLIGHT TESTING FOR BETTER FLIGHT TRAINING SIMULATORS**
W. G. SCHWEIKHARD and R. R. L. RENZ (Kohlman Systems Research, Inc., Lawrence, KS) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9728)

The development of a data acquisition system for flight simulation testing is described. The flight test instrumentation and analysis techniques required for testing the aircraft are examined. The flight testing of thirteen business jets and one turboprop aircraft is discussed. Problems encountered in the formation of the data acquisition system are analyzed. I.F.

**A86-37082#**
**AV-8B HIGH ANGLE OF ATTACK/DEPARTURE RESISTANCE SYSTEM FLIGHT TEST PROGRAM**
R. A. BIGLER (McDonnell Aircraft Co., St. Louis, MO) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p.
(AIAA PAPER 86-9729)

The AV-8B High Angle of Attack (HAOA) Test Program used a four phase approach to accomplish the goals within the established time constraints. The major goals were evaluating the HAOA flight characteristics as required by military specification and developing stability augmentation software to enhance the aircraft's maneuvering capability. These goals were accomplished during a thirteen month/251 flight program which incorporated Naval Air Test Center participation flights throughout to eliminate extraneous testing and provide the customer with an early appraisal of the HAOA characteristics. The flight test program concluded with a dedicated spin mode and recovery investigation. The test results defined the maneuvering boundary and indicated the aircraft possessed a high resistance to spin dynamics throughout the normal flight regime. Author

**A86-37108**
**STRUCTURAL CERTIFICATION AND IN-SERVICE FLIGHT EXPERIENCE OF THE RB 211-524 FAN COWL DOORS UTILISING CARBON FIBRE COMPOSITE MATERIALS**
B. P. BROADLEY (Rolls-Royce, Ltd., Derby, England) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 118-134. refs

**N86-24685*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**GROUND VIBRATION TEST OF AN F-16 AIRPLANE WITH MODIFIED DECOUPLER PYLONS**
F. W. CAZIER, JR., and M. W. KEHOE (NASA. Dryden Flight Research Center) Apr. 1986 64 p refs
(NASA-TM-87634; L-16065; NAS 1.15:87634) Avail: NTIS HC A04/MF A01 CSCL 01C

The decoupler pylon is a passive wing/store flutter suppression device. It was modified to reduce friction following initial flight tests. A ground vibration test was conducted on an F-16 aircraft loaded on each wing with a one-half-full (center bay empty) 370-gallon fuel tank mounted on a standard pylon, a GBU-8 store mounted on the decoupler pylon, and an AIM-9J missile mounted on a wingtip launcher. The test was conducted prior to flight tests with the modified pylon to determine modal frequencies, mode shapes, and structural damping coefficients. Data presented include frequency response plots, mode shape plots, and limited force-effect plots. Author

**N86-24687*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**AN ENGINEERING APPROACH TO THE USE OF EXPERT SYSTEMS TECHNOLOGY IN AVIONICS APPLICATIONS**

E. L. DUKE, V. A. REGENIE, M. BRAZEE, and R. W. BRUMBAUGH (PRC Kentron, Edwards, Calif.) May 1986 12 p refs Presented at the IEEE National Aerospace and Electronics Conference (NAECON), Dayton, Ohio, 19-23 May 1986

(NASA-TM-88263; H-1364; NAS 1.15:88263) Avail: NTIS HC A02/MF A01 CSCL 01D

The concept of using a knowledge compiler to transform the knowledge base and inference mechanism of an expert system into a conventional program is presented. The need to accommodate real-time systems requirements in applications such as embedded avionics is outlined. Expert systems and a brief comparison of expert systems and conventional programs are reviewed. Avionics applications of expert systems are discussed before the discussions of applying the proposed concept to example systems using forward and backward chaining. Author

**N86-24688#** Boeing Military Airplane Development, Seattle, Wash.

**FIREPROOF HYDRAULIC BRAKE SYSTEM Final Report, 1 Jul. 1983 - 31 Jul. 1985**

D. W. HULING and F. H. HILLMAN Oct. 1985 318 p refs

(Contract F33615-83-C-2322)

(AD-A163542; AFWAL-TR-85-2072) Avail: NTIS HC A14/MF A01 CSCL 01C

The design, development, and manufacture of a flightworthy two-fluid fireproof hydraulic brake system (FHBS) kit for flight testing on a C/KC-135 has been accomplished. The results of system concepts trade studies, the concept selection procedure and rational, component and system design analyses, and component and system testing are summarized herein. The FHBS design selected is a two-fluid concept that uses nonflammable chlorotrifluoroethylene (CTFE) in the high fire-potential area of the brake and landing gear area. The barrier between the CTFE fluid and the MIL-H-5606 hydraulic fluid is a new component; a reservoir/separator. Based on the analysis and laboratory testing, it was concluded that the FHBS design is both flightworthy and has braking performance equivalent to the C/KC-135 brake system for runway/tire friction coefficients of 0.2 to 0.5. It is recommended that the FHBS kit be installed on a C/KC-135 and flight testing be accomplished. Recommendations regarding test conditions and instrumentation for flight testing are included. GRA

**N86-24689#** Department of the Air Force, Washington, D.C.

**FRAMELESS TRANSPARENCIES FOR AIRCRAFT COCKPIT ENCLOSURES Patent Application**

W. R. PINNELL, inventor (to Air Force) 4 Dec. 1985 18 p refs

(AD-D012155; US-PATENT-APPL-SN-805008) Avail: NTIS HC A02/MF A01 CSCL 01C

This patent application is for a frameless aircraft cockpit enclosure comprising transparent panels of polycarbonate or other plastics of varying thickness and material properties. The edges of the transparent panels are made thicker than the rest of the panels to engage aircraft canopy and windshield arch sections and aircraft sill structures to thus eliminate prior art frames and edge reinforcements. Fibers may be embedded in the thicker edges to add strength. The material properties of the transparent panel may be varied to provide higher static load strength near aircraft sill structures and higher dynamic load strength and plastic behavior near the center of a canopy where bird impact may occur. The material properties of the panel may also be varied to minimize over a pilot's head or near aircraft critical equipment the amplitude of a flexure wave in an aircraft transparency resulting from a bird impact. Direct forming methods, such as injection molding, are discussed as a means for making the frameless aircraft transparencies. GRA

**N86-24690#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**EXPERIMENTAL ASSESSMENT OF VORTEX RETAINING CAVITY FLAPS FOR MANEUVERABILITY IMPROVEMENT ON DELTA WING FIGHTER AIRCRAFT M.S. Thesis**

H. C. SMITH Dec. 1985 244 p refs

(AD-A164104; AFIT/GAE/AA/85D-13) Avail: NTIS HC A11/MF A01 CSCL 01C

An experimental study was conducted to determine the effectiveness of cavity flaps on delta wing aircraft maneuverability. Cavity flaps are conformal control surfaces deployed in the apex region on the wing's lower surface. A 60 degree swept delta wing model was built and tested in the Air Force Institute of Technology five-foot diameter, subsonic wind tunnel. Ten different cavity flap configurations were tested at deflection angles ranging from 30 degrees to 90 degrees for both asymmetric and symmetric deployments. Coefficients of aerodynamic forces and moments versus angle of attack along with the lift to drag ratio versus lift coefficient and the drag polar were plotted for each flap configuration. The changes to the aerodynamic coefficients produced by adding the cavity flaps were also plotted. Results indicate that for longitudinal, lateral and directional maneuverability, the best cavity flap deflection angle will vary depending on the desired response. Data results also indicated it is best not to have the cavity flap hinge line located along or parallel to the fuselage for rolling and pitching moment considerations. Hinge Line Sweep. GRA

**N86-25338** ESDU International Ltd., London (England). Engineering Sciences Data Unit.

**CONVERSION OF AIR-DATA SYSTEM PRESSURE ERRORS INTO HEIGHT AND SPEED CORRECTIONS**

Nov. 1985 37 p refs

(ESDU-85036; ISBN-0-85679-542-9; ISSN-0141-4054) Avail: ESDU

Approximate formulae for converting errors in pitot and static pressure into corrections to height, Mach number and indicated airspeed are presented as both equations and graphs. The methods give acceptable accuracy for constructing charts or tables of height and speed corrections for flight and operating manuals when pressure errors are not large. Exact methods for correcting speed and height are also included for use when the pressure errors are large, and guidance is included on the correction procedure under nonsteady conditions when any of the errors may depend on the height, Mach number or airspeed. A practical work example illustrates the use of the method. Author

**N86-25339#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**EVALUATION OF A FREQUENCY RESPONSE TECHNIQUE FOR AIRCRAFT SYSTEM IDENTIFICATION M.S. Thesis Final Report, Feb. 1984 - Oct. 1985**

A. T. REED 31 Oct. 1985 108 p refs

(AD-A164367; AFIT/GAE/AA/85J-2) Avail: NTIS HC A06/MF A01 CSCL 01A

This paper presents the results of a project which used frequency analysis methods applied to flight test data in order to identify aircraft parameters. Computer programs were developed to generate simulated flight test data so the frequency response programs could be tested using a noise free data source. Once the simulated data programs were complete, the frequency response methods were developed. The frequency response method uses the cross-spectral density technique to generate magnitude and phase information. The program also generates the power spectral density functions. Noise contamination studies were made. The programs were used with the test project, HAVE DELAY, which was conducted at the USAF Test Pilot School. The frequency response program worked well up to a frequency of about 15 radians per second. Above 15 radians per second the programs suffer from additional noise and aliasing effects. Recommendations were made to study means of reducing noise effects to include anti-aliasing filters and noise processing schemes for digital data. GRA

**N86-25340#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**MULTIVARIABLE OUTPUT CONTROL LAW DESIGN FOR THE STOL (SHORT TAKEOFF AND LANDING) F-15 IN LANDING CONFIGURATION M.S. Thesis**

B. H. ACKER Dec. 1985 294 p refs
(AD-A164516; AFIT/GE/ENG/85D-1) Avail: NTIS HC A13/MF A01 CSCL 01B

Using the MULTI computer aided design and simulation program, multivariable, output feedback digital control laws are designed for the F-15 STOL aircraft in the landing configuration. The STOL F-15 landing configuration includes canards and reversible thrust in addition to conventional F-15 control surfaces. The additional controls allow decoupling of the output variables in the longitudinal plane. Longitudinal aircraft dynamics, derived from data provided by the prime contractor, McDonnell-Douglas, are presented in linearized state space form for the design procedure. Control laws are developed to stabilize the aircraft to perform longitudinal landing maneuvers (flight path control and flare) at six flight conditions. The design encompasses actuator dynamics, computational delay, sensor dynamics, sensor noise, and plant nonlinearities. Designs of two of the flight conditions are sufficiently insensitive to plant variations to be used at all but one of the remaining flight conditions. The technique of multivariable output feedback, with the MULTI program provides good robust designs for the STOL F-15. GRA

**N86-25341#** Aeronautical Research Labs., Melbourne (Australia).

**REPORT ON INTEREST EXPRESSED IN SOME AUSTRALIAN DEFENCE ESTABLISHMENT PRODUCTS DISPLAYED AT THE 1985 PARIS AIR SHOW**

U. R. KRIESER Aug. 1985 29 p
(AD-A160807; ARL-AERO-PROP-TM-429; AR-004-040) Avail: NTIS HC A03/MF A01 CSCL 01C

During June 1985 a number of aerospace products developed in Australia were displayed at the Paris Air Show. The Department of Defense was one of 16 exhibitors, and presented 14 products which it considered to have commercial potential on the world market. Considerable interest was shown in the Department of Defense products presented in Paris, and subsequent visits to aerospace companies in Israel, further demonstrated strong overseas interest in both manufacture and purchase of these products. Author

**N86-25601#** Joint Publications Research Service, Arlington, Va.

**INFORMATION ON NEW AN-124 GIANT CARGO PLANE Abstract Only**

N. DOMBKOVSKIY *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 4 7 Feb. 1986 Transl. into ENGLISH from Trud (Leningrad, USSR), 23 May 1985 p 1
Avail: NTIS HC A06/MF A01

The dimensions and capabilities of the AN-124 cargo aircraft are described. The problems that were involved in the aircraft design are also characterized. B.G.

**N86-25602#** Joint Publications Research Service, Arlington, Va.

**DATA ON MI-26 HELICOPTER Abstract Only**

L. CHERNOV *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 7-8 7 Feb. 1986 Transl. into ENGLISH from Kommunist (Moscow, USSR), 19 May 1985 p 4
Avail: NTIS HC A06/MF A01

The MI-26 helicopter, which has the highest payload capacity of any existing helicopter, can transport items that weigh more than 20 tons over long distances in severe climatic conditions. The helicopter is used in the construction of bridges and other structures, and in the delivery and installation of heavy equipment for industrial enterprises and drilling rigs in remote areas. The increased power of the MI-26 was achieved through the use of new materials, structural design, and two economic D-136 gas turbine engines. The design and arrangement of the MI-26 systems make ground maintenance possible without special airfield equipment. An auxiliary power unit ensures the prolonged operation of the helicopter. For mechanization of loading operations, the cargo bay is equipped with two electric winches and a hoisting mechanism which can handle cargo items up to 5 tons each. With a length of 15 meters, the cargo bay can easily hold two trucks or motor buses. B.G.

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-33583*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AN AIRBORNE MULTIPLE-BEAM 1.4 GHZ PUSHBROOM MICROWAVE RADIOMETER**

R. F. HARRINGTON and R. W. LAWRENCE (NASA, Langley Research Center, Hampton, VA) IN: 1985 International Geoscience and Remote Sensing Symposium (IGARSS '85), Amherst, MA, October 7-9, 1985, Digest. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 601-606.

A method is described for providing soil moisture measurements from satellites by performing simultaneous measurements across track (the pushbroom approach). The method has the advantage of obtaining the required swath width without sacrificing sensitivity. A prototype Pushbroom Microwave Radiometer developed at NASA's Langley Research Center is described. It is a multibeam L-Band (1413 MHz) radiometer system providing simultaneous cross track measurements. Results of flight tests onboard a P-3 aircraft are discussed. D.H.

**A86-33590*** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**HIGH RESOLUTION MILLIMETER-WAVE IMAGING SENSOR**

W. J. WILSON, R. J. HOWARD, and G. S. PARKS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1985 International Geoscience and Remote Sensing Symposium (IGARSS '85), Amherst, MA, October 7-9, 1985, Digest. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 647-649. Army-supported research.

A scanning 3-mm radiometer is described that has been built for use on a small aircraft to produce real time high resolution images of the ground when atmospheric conditions such as smoke, dust, and clouds make IR and visual sensors unusable. The sensor can be used for a variety of remote sensing applications such as measurements of snow cover and snow water equivalent, precipitation mapping, vegetation type and extent, surface moisture and temperature, and surface thermal inertia. The advantages of millimeter waves for cloud penetration and the ability to observe different physical phenomena make this system an attractive supplement to visible and IR remote sensing systems. D.H.

**A86-33602*** Michigan Univ., Ann Arbor.

**HEAD-UP DISPLAY (HUD) UTILITY. II - RUNWAY TO HUD TRANSITIONS MONITORING EYE FOCUS AND DECISION TIMES**

D. J. WEINTRAUB (Michigan, University, Ann Arbor), R. F. HAINES, and R. J. RANDLE (NASA, Ames Research Center, Moffett Field, CA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1985, p. 615-619.
(Contract NCA2-OR-440-301)

An experiment conducted using a head-up display (HUD) suggests that the demonstrated superiority of the HUD over a conventional instrument panel stems from its superior layout of information. A HUD display presents instrument-panel information to pilots in such a way that the symbols appear as a virtual image at optical infinity superimposed on the landscape. In the experiment conducted, the luminance of the display symbology and its angle subtended at the eye remained fixed, while optical distance and gaze angle were varied. Concomitant measures of eye movements, eye accommodative state, and decision-making time concerning airspeed, altitude and runway condition were obtained. It is found that, while looking straight ahead, at zero diopters, the HUD shortens decision time by 80 to 90 msec, not statistically significant at the 0.05 (slope of diopter/gaze interaction) level. The question of a cognitive overload induced by the luminous symbols of the HUD is subsequently addressed. K.K.

**A86-33814**

### COCKPIT AUTOMATION TECHNOLOGY - A FURTHER LOOK

M. D. MCNEESE, R. WARREN, and B. K. WOODSON (USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, OH) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1985, p. 884-888. refs

Issues related to the development of a structured human factors crew station design methodology are discussed. The benefits to pilots, design teams, and the US Air Force from cockpit automation technology (CAT) design methodology are described. The relationship between CAT components and procedures, and the user's needs is studied. The iterative cycle of the methodology and the parameterization of CAT components are analyzed. I.F.

**A86-34276#**

### STUDIES ON TURNING ERRORS OF THE MAGNETIC COMPASS IN FLIGHT EXPERIMENTS

T. HIDESHIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 385, 1986, p. 74-80. In Japanese, with abstract in English. refs

To clarify the behavior of turning errors of the magnetic compass, many turns are conducted from various courses by the trainers of Civil Aviation College. In turning to the right, the maximal lag error of the compasss occurs between the heading of 10 and 40 deg, and the maximal lead error occurs between the heading of 130 and 160 deg. The extent of the maximal error depends upon the angle of aircraft bank. An angle of bank has the greatest effect on compass errors among the flight characteristics of an aircraft. The effect of flying speed, the time rate of bank and flying altitude are investigated. The results of flight experiments agree quite well with those of computing errors through Lindemann's procedure. As a result of the studies, turning error curve is proposed. The computed turning error curves to one angle of bank are almost the same for the compasses used today. This curve can be applied to any turning by using the magnetic compass. Author

**A86-35207**

### WEIGHT ASSESSMENT OF ELECTRONIC BOXES

L. A. HARTLEY and O. HANREITER (Boeing Military Airplane Co., Wichita, KS) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 37 p. (SAWE PAPER 1661)

The present paper is concerned with the prediction and assessment of the weights of electronic boxes on a new aircraft. A statistical basis is provided for the evaluation of weights of electronic boxes, taking into account the use of simple parameters which are universally available. The Offensive and Defensive System avionics developed for the B-1 bomber program provide a sufficiently large data base to permit development of a statistical basis for evaluating electronic box weights. It is found that a distinct electronic box, which is called a Line Replaceable Unit (LRU), can undergo tremendous weight growth. Attention is given to a data base description, LRU construction, aspects of program phasing and milestones, sources of uncertainty for new hardware, sources of uncertainty for off-the-shelf hardware, statistical data, probability curves defined, parameters defined, probability of LRU weight growth, LRU weight density probability, a weight quality history, and aspects of data application. G.R.

**A86-35366*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### A PRELIMINARY STUDY OF THE BASIC DISPLAY/GUIDANCE REQUIREMENTS FOR FLYING NEAR OPTIMAL TRAJECTORIES

D. D. VICROY (NASA, Langley Research Center, Hampton, VA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 669-674. refs

NASA has responded to the increased emphases on cost-efficient operation of today's airline fleet with an ongoing research program to investigate the requirements and benefits of using new airborne guidance and pilot procedures designed to yield cost-optimal flight profiles that are compatible with advanced air traffic control system concepts. A trajectory optimization algorithm has been incorporated into one of NASA Langley's fixed-based simulators to investigate the pilot/cockpit interface requirements. The trajectories that are generated by this algorithm differ from conventional profiles in that they are constantly varying in both flight path angle and airspeed. Considering the dynamic nature of these profiles, conventional guidance may be insufficient for practical use. This paper summarizes the results of an initial set of piloted simulation tests to investigate the basic guidance requirements for flying the near-optimal trajectories. Author

**A86-35439**

### COMPUTER-AIDED COCKPIT WORKLOAD ANALYSIS FOR ALL WEATHER, MULTIROLE TACTICAL AIRCRAFT

B. B. ROBERTS (Computer Sciences Corp., Edwards AFB, CA) and C. D. CRITES (USAF, Flight Test Center, Edwards AFB, CA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 111-123. (SAE PAPER 851876)

The development of computer-aided cockpit workload analysis that predicts man/machine interface problems is discussed. The logic flow for the Timebased Analysis of Significant Coordinated Operations (TASCO) model is described. The components and procedures of the crew station task analysis and busy rate index analysis performed by the TASCO model are examined. Computer-aided testing is applied to the TASCO model to establish pass/fail criteria associated with operator task performance profficiency. I.F.

**A86-35606**

### STORED TERRAIN DATA BASE AIDED PILOTAGE FOR HELICOPTERS

N. C. SEILER and J. A. GRACIA (Harris Corp., Harris Government Aerospace Systems Div., Melbourne, FL) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 101-109. refs

A panoramic pilotage display, enhanced by a topographical data base, can significantly improve military helicopter pilot efficiency while reducing workloads. The basic task of geographic orientation is automated through the provision of a planview map with tactical symbology on a head-down display. The stored data base required allows for a look-ahead capability from topographical cover positions; this is especially useful when presented in a perspective format on the head-down display. A system of this type is applicable to the U.S. Army's next-generation 'LHX' single-crewmember combat helicopter. O.C.

**A86-35650**

### AN AVIONICS SOFTWARE TEST AND EVALUATION TECHNIQUE

T. B. PRIEST, JR. and B. P. DOUGLASS (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 661-664.

Quality control must be ensured for advanced helicopter avionics systems requiring complex software for the performance of a variety of tasks; attention is presently given to a four-phase software testing method of this type. The phases are: (1) individual software module testing; (2) testing of the complete program constructed from the linked modules; (3) real time, manned tests with simulated inputs; and (4) flight testing. O.C.

**A86-35666#**

**INTEGRATED AVIONICS SUITE AS IMPLEMENTED ON THE AGUSTA A-129**

K. E. FARSON (Harris Corp.; Government Aerospace Systems Div., Melbourne, FL) AHS, Annual Forum and Technology Display, 41st, Fort Worth, TX, May 15-17, 1985, Paper. 12 p.

The integrated avionics suite implemented on the Agusta A-129 attack helicopter is described. The integrated Multiplex System (IMS), performing all of the on-board subsystem management, processing, data transfer, display, and control is the main asset of the craft, with features including pilot and copilot multimode displays, dual redundant mission processors, dual MIL-STD-1553B data bus network, electrical power management through solid-state power controllers, and modular software. Implementation of IMS into the helicopter meant a reduction in the number of required LRUs, lower total system weight, incrased reliability, and improved performance. The extremely flexible system architecture allows for changes and growth. I. S.

**A86-36725**

**DIGITAL CORRECTION OF THE READINGS OF AN AIRCRAFT FUEL-MEASUREMENT SYSTEM [TSIFROVAIA KORREKTSIIA POKAZANII TOPLIVOIZMERITEL'NOI SISTEMY LETATEL'NOGO APPARATA]**

A. L. ALIMOV Avtometriia (ISSN 0320-7102), Jan.-Feb. 1986, p. 100-102. In Russian.

The paper examines the compression and compact storage of data required for the digital correction of the readings of an aircraft fuel-measurement system. It is shown that memory-size minimization involves the division of a special graph into a minimum number of complete subgraphs. A heuristic algorithm for solving this model is proposed. B.J.

**A86-37045*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CRASH RESPONSE DATA SYSTEM FOR THE CONTROLLED IMPACT DEMONSTRATION (CID) OF A FULL-SCALE TRANSPORT AIRCRAFT**

R. S. CALLOWAY and V. H. KNIGHT, JR. (NASA, Langley Research Center, Hampton, VA) ISA, International Instrumentation Symposium, 32nd, Seattle, WA, May 5-8, 1986, Paper. 20 p.

A study involving the Controlled Impact Demonstration (CID) of a transport category aircraft was conducted with the objective to improve occupant safety during survivable crash scenarios. In connection with this study, the first remotely-piloted Full-Scale Transport aircraft was purposely crashed into the California desert. The program was initated to demonstrate the effectiveness of an imisting kerosene (AMK), a fuel additive emplyed to reduce postcrash fires. The unmanned CID flight carried 73 life-like flight research dummies, multiple experiments, high-speed interior cabin cameras, and the high-environment Crash Response Data System. Attention is given to the design approach, a block diagram of the Crash Response Data System, measurements, the digital data subsystem, signal conditioning, telemetry, on-board recording, the power subsystem, preflight checkout and calibration, and aspects of system qualification. G.R.

**A86-37083*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ADVANCED BOUNDARY LAYER TRANSITION MEASUREMENT METHODS FOR FLIGHT APPLICATIONS**

B. J. HOLMES, C. C. CROOM, P. D. GAIL, G. S. MANUEL, and D. L. CARRAWAY (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 14 p. refs

(AIAA PAPER 86-9786)

In modern laminar flow flight research, it is important to understand the specific cause(s) of laminar to turbulent boundary-layer transition. Such information is crucial to the exploration of the limits of practical application of laminar flow for drag reduction on aircraft. The transition modes of interest in current flight investigations include the viscous Tollmien-Schlichting instability, the inflectional instability at laminar separation, and the crossflow inflectional instability, as well as others. This paper presents the results to date of research on advanced devices and methods used for the study of laminar boundary-layer transition phenomena in the flight environment. Recent advancements in the development of arrayed hot-film devices and of a new flow visualization method are discussed. Arrayed hot-film devices have been designed to detect the presence of laminar separation, and of crossflow vorticity. The advanced flow visualization method utilizes color changes in liquid-crystal coatings to detect boundary-layer transition at high altitude flight conditions. Flight and wind tunnel data are presented to illustrate the design and operation of these advanced methods. These new research tools provide information on disturbance growth and transition mode which is essential to furthering our understanding of practical design limits for applications of laminar flow technology. Author

## 07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-33970**

**FATIGUE FAILURE OF JET ENGINE DRIVE SHAFTS**

H. J. KOLKMAN and J. P. K. VLEGHERT (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) International Journal of Fatigue (ISSN 0142-1123), vol. 8, Jan. 1986, p. 3-8.

The cause and prevention of service failures of jet engine drive shafts was investigated by various methods. A materials investigation revealed a low fatigue resistance associated with material deficiencies for certain shafts, including the failed ones. Nevertheless the final and most economic solution to the problem was found by vibration analysis. Author

**A86-34279#**

**THE SUPERPOSITION DISTORTION INDEX**

T. ABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 385, 1986, p. 97-106. In Japanese, with abstract in English. refs

In this paper, a superposition distortion index KA2 is introduced to indicate the relationship between the distortion intensity and the fan speed. The data to calulate the KA2 was obtained by the distortion experiments using the two stages axial flow fan and distortion screens. A number of conventional distortion indices such as Kra2, DI, Dmin, K-theta, KD2, and DC60 are presented to evaluate the each radial and circumferential distortion intensity. In a previous paper, both radial and circumferential distortion indices were expressed in one figure to evaluate the distortion intensity more accurately. This method, however, cannot tell the influence of the fan speed. The index KA2 includes the radial distortion index Kra2 and the circumferential distortion index K-theta, the

influence of fan speed. The influence of fan speed was obtained from the stall margin decrease of the fan chracteristics curves.
Author

**A86-35168#**

**PROCEDURES FOR THE DIGITAL SIMULATION OF HELICOPTER PROPULSION SYSTEMS [VERFAHREN ZUR DIGITALEN SIMULATION VON HUBSCHRAUBER-ANTRIEBSSYSTEMEN]**

M. MENRATH and H. RICK (Muenchen, Technische Universitaet, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 31 p. In German. refs
(DGLR PAPER 85-115)

The advances made in aircraft engine technology are partly related to the available simulation methods for the design and the optimization of propulsion systems, and, in addition, also to the study of the steady and dynamic performance and operational characteristics of the entire system aircraft-engine. Numerical synthesis programs for the digital simulation of steady and dynamic operational characteristics of propulsion systems are discussed, taking into account engine monitoring with a gas dynamic diagnosis procedure. Attention is also given to the digital simulation of the dynamic operational characteristics with function generators, digital simulation according to 'state space models', and test stand technology for the development of simulation models. G.R.

**A86-35188#**

**THE PROP-FAN - INITIATION FOR A NEW GENERATION OF PROPULSION SYSTEMS [DER PROPFAN - INITIALZUENDUNG FUER EINE NEUE TRIEBWERKSGENERATION]**

P. SCHIMMING (DFVLR, Institut fuer Antriebstechnik, Cologne, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 11 p. In German.
(DGLR PAPER 85-166)

New applications of prop-fans are briefly discussed. The advantages of prop-fans are reviewed, and studies being conducted to evaluate the spectrum of possible propulsion systems using prop-fans are summarized. Concepts now being explored for ameliorating the drawbacks of prop-fans are described. C.D.

**A86-35334**

**GAIN-SCHEDULED MULTIVARIABLE COTNROL FOR THE GE-21 TURBOFAN ENGINE USING THE LQG/LTR METHODOLOGY**

P. KAPASOURIS, M. ATHANS, and H. A. SPANG, III (MIT, Cambridge, MA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 109-118. Research supported by the General Electric Co. refs

This paper presents a feasibility study related to the design of a global nonlinear multivariable compensator for a model of the GE-21 double-bypass variable cycle jet engine. The nonlinear engine dynamics are linearized at nine distinct operating conditions. Scaling of variable units and Singular Value Decomposition at DC identified the subset of controls and outputs for dynamic control. At each operating condition an LQG/LTR compensator is designed; the parameters of the LQG/LTR compensator are then scheduled to produce a global dynamic compensator. Transient simulations are included to illustrate the characteristics of the nonlinear multivariable control system. Author

**A86-35400*** Alphatech, Inc., Burlington, Mass.

**APPLICATION OF FDI METRICS TO DETECTION AND ISOLATION OF SENSOR FAILURES IN TURBINE ENGINES**

J. L. WEISS, A. S. WILLSKY, K. R. PATTIPATI, and J. S. ETERNO (Alphatech, Inc., Burlington, MA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1114-1120. refs
(Contract NAS3-24078)

This paper develops a framework for the design of failure detection and isolation (FDI) algorithms. Rather than trying to apply 'optimal' techniques in a top-down manner, the system redundancies are evaluated with respect to their ability to provide reliable FDI information. Previous work of Pattipati et al. (1984) and Weiss et al. (1984) defined a useful context and several useful analytical results, which provide a basis for the FDI design methodology developed here. A general decision structure which can take advantage of redundancy evaluation is presented, and examples of typical design considerations are discussed. The operation of the decision structure is then demonstrated for a sensor FDI application involving the F-100 jet engine. Author

**A86-35402*** Systems Control Technology, Inc., Palo Alto, Calif.

**ROBUST DETECTION, ISOLATION, AND ACCOMMODATION FOR SENSOR FAILURES**

A. EMAMI-NAEINI, M. M. AKHTER, and S. M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1129-1134. refs
(Contract NAS3-24079)

Recent advances in multivariable robust control system design are extended to sensor failure, detection, isolation, and accommodation (FDIA) and estimator design. A new concept called threshold selector is introduced. It represents a significant and innovative tool for the analysis and synthesis of FDIA algorithms. Analytical results are obtained for the SISO case to compute optimal thresholds and size of minimum detectable failures, and a computer-aided technique is developed for the multivariable case. The techniques have been applied to sensor FDIA for an aircraft turbine engine control system. Author

**A86-35403*** Scientific Systems, Inc., Cambridge, Mass.

**BIFURCATION TECHNIQUES FOR NONLINEAR DYNAMIC ANALYSIS OF COMPRESSOR STALL PHENOMENA**

H. C. RAZAVI and R. K. MEHRA (Scientific Systems, Inc., Cambridge, MA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1135-1142. refs
(Contract NAS3-24089; NSF CEE-81-00491)

Compressor stall phenomena is analyzed from nonlinear control theory viewpoint, based on bifurcation-catastrophe techniques. This new approach appears promising and offers insight into such well known compressor instability problems as surge and rotating stall; furthermore it suggests strategies for recovery from stall. Three interlocking dynamic nonlinear state space models are developed. It is shown that the problem of rotating stall can be viewed as an (induced) bifurcation of solution of the unstalled model. Hysteresis effect is shown to exist in the stall/recovery process. Surge cycles are observed to develop for some critical parameter values. It is shown that the oscillatory behavior is due to development of limit cycles, generated by Hopf bifurcation of solutions. Both stable and unstable limit cycles are observed. To further illustrate the usefulness of the methodology some partial computation of domains of attraction of equilibria is carried out, and parameter sensitivity analysis is performed. Author

**A86-35412**

**SYNTHESIS OF SYSTEM RESPONSES - A NONLINEAR MULTIVARIABLE CONTROL DESIGN APPROACH**

J. L. PECZKOWSKI (Allied-Bendix Aerospace, Bendix Energy Controls Div., South Bend, IN) and M. K. SAIN (Notre Dame, University, IN) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1181-1186. refs
(Contract NAS2-11877)

A unique feedback controller structure using coordinated feedforward and feedback dynamics is presented, with emphasis on the application aspects of system response. The control approach linearizes the plant at a finite number of points over the envelope of operation, applies linear transfer synthesis techniques about each point to obtain desired output responses and acceptable control responses, and systematically links and schedules all local designs together into a global design over the envelope as a function of key plant variables within a broad nonlinear design strategy. The synthesis is illustrated by the design of nonlinear control systems for a turbojet engine. B.J.

**A86-35472**
**PRACTICAL DIAGNOSTICS OF AIRCRAFT GAS TURBINES [PRAKTICHESKAIA DIAGNOSTIKA AVIATSIONNYKH GAZOTURBINNYKH DVIGATELEI]**
L. P. LOZITSKII, V. P. STEPANENKO, V. A. STUDENIKIN, V. F. LAPSHOV, M. D. AVDOSHKO et al. Moscow, Izdatel'stvo Transport, 1985, 104 p. In Russian. refs

The methods and equipment used in the testing and troubleshooting of aircraft gas turbines are reviewed. In particular, attention is given to the principal types of faults and malfunctions and their diagnostic parameters; detectability of faults; and the organizational and technical aspects of diagnostic support. The discussion also covers particular diagnostic techniques based on flight data, vibration parameters, thermogasdynamic parameters, and wear products accumulating in oil. Finally, the automation of testing and troubleshooting and future prospects in this field are discussed. V.L.

**A86-35612**
**APPLICATION OF CFD DESIGN TECHNOLOGY IN DEVELOPMENT OF THE JVX ENGINE INLET**
G. C. PAYNTER, J. L. KONCSEK (Boeing Military Airplane Co., Seattle, WA), B. TURCZENIUK (Boeing Vertol Co., Philadelphia, PA), D. R. CLARK, and D. J. STRASH (Analytical Methods, Inc., Bellevue, WA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 163-174. refs

A joint services program is underway to develop a tilt rotor vertical lift aircraft, the V-22 Osprey, previously the JVX, for amphibious assault, combat search and rescue, special operations and electronic warfare. The engine inlets for this aircraft must supply air to the engines with high recovery and low distortion under all operational modes without an increase in overall aircraft drag at cruise due to inlet flow spillage. In addition, the inlet must prevent sand ingested into the inlet from passing through the engine. This paper describes the CFD based design procedure which was used to configure the engine inlet and the wind tunnel testing which was used to validate the design. Wind tunnel tests confirmed that the inlet would meet or exceed its performance goals. Author

**A86-35614*** General Electric Co., Lynn, Mass.
**THE APPLICATION OF LQR SYNTHESIS TECHNIQUES TO THE TURBOSHAFT ENGINE CONTROL PROBLEM**
W. H. PFEIL, G. DE LOS REYES (General Electric Co., Aircraft Engine Business Group, Lynn, MA), and G. A. BOBULA (NASA, Lewis Research Center; U.S. Army, Propulsion Laboratory, Cleveland, OH) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 189-196. refs
(Contract NAS3-22763)

A power turbine governor was designed for a recent-technology turboshaft engine coupled to a modern, articulated rotor system using Linear Quadratic Regulator (LQR) and Kalman Filter (KF) techniques. A linear, state-space model of the engine and rotor system was derived for six engine power settings from flight idle to maximum continuous. An integrator was appended to the fuel flow input to reduce the steady-state governor error to zero. Feedback gains were calculated for the system states at each power setting using the LQR technique. The main rotor tip speed state is not measurable, so a Kalman Filter of the rotor was used to estimate this state. The crossover of the system was increased to 10 rad/s compared to 2 rad/sec for a current governor. Initial computer simulations with a nonlinear engine model indicate a significant decrease in power turbine speed variation with the LQR governor compared to a conventional governor. Author

**A86-35615**
**ADAPTIVE FUEL CONTROL TESTING**
D. M. ACHGILL (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and R. D. ZAGRANSKI (Colt Industries, Inc., Chandler Evans Control Systems Div., West Hartford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 197-211.
(Contract DAAK51-83-C-0038)

Closed loop bench tests, 250-C30 engine tests, man-in-the-loop S76 simulator sessions, and 206L helicopter flight tests, are being conducted as part of a U.S. Army program for the evaluation of full authority digital engine control-implemented concepts. The adaptive control laws encompass engine start sequence variation as a function of speed and acceleration, sensing of compressor discharge pressures, measuring engine deceleration rates, adding torsional mode damping to the rotor drive-train, and sensing rotor speed decay rate. Test results indicate that substantial engine and helicopter performance paybacks are achieved with these control features. O.C.

**A86-35865#**
**VIBRATION CHARACTERISTICS OF AIRCRAFT ENGINE-BLADED-DISK ASSEMBLY**
J. S.J RAO, C. B. SHAH, CH. L. GANESH (Indian Institute of Technology, New Delhi, India), and Y. V. K. S. RAO (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandum, India) Defence Science Journal (ISSN 0011-748X), vol. 36, Jan. 1986, p. 9-26. Research supported by the Defence Ministry. refs

This paper is concerned with the vibration characteristics of a gas-turbine blade-disk assembly and a third stage of compressor blade-disk assembly of an orpheus aircraft engine. The assembly is analyzed by considering each component individually and then combining them together with a receptance coupling technique by matching forces and displacements at each junction point. The blade is modeled by number of free-free aerofoil section beams staggered at different angles to the plane of the disk, and the nonuniform disk is modeled as number of concentric annuli. The natural frequencies and mode shapes for each case have been obtained. Results obtained are verified by testing both the above assemblies on a microprocessor based vibration exciter and real time analyzer. The mode shape corresponding to each natural frequency was obtained by probing with hand held accelerometer Author

**A86-35992**
**LIMITING VALUES OF THE SPECIFIC PARAMETERS OF A RAMJET ENGINE [O PREDEL'NYKH ZNACHENIIAKH UDEL'NYKH PARAMETROV PVRD]**
V. I. BAZHANOV and A. A. STEPCHKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 77, 78. In Russian.

The parameters of a ramjet engine using a supersonic diffuser with 2, 3, and 4 shock waves are calculated in the Mach number range 4-8. It is shown that the engine parameters are improved with increasing flight velocity, this effect being particularly pronounced in the range Mach 4-6; only a slight improvement is observed at Mach greater than 6. An increase in the number of shock waves in the diffuser above three does not change the specific thrust or specific fuel consumption by more than 5 percent. V.L.

**A86-36336**
**AIRCRAFT ENGINE TECHNOLOGY WINDOWS (LECTURE)**
B. H. ROWE (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) Aerospace (UK) (ISSN 0305-0831), vol. 13, April 1986, p. 23-27.

The success or failure of a manufacturing company depends on the ability to recognize technological windows, a confluence of developments which can be exploited to realize a successful product. New propulsion systems are the key to smaller, lighter, lower-cost, higher efficiency aircraft aircraft. Improvements are largely made with refinements of existing technologies, those for which capital investments in plant can be amortized over sufficiently short periods of time. In R&D, attention is currently focused on unducted fans (UDF) for subsonic flight, augmented turbo fans for supersonic flight, and combinations of the airbreathing engines and rocket power for military and commercial hypersonic flight. The UDF, as NASA tests have shown, offers a potential 25 percent greater efficiency than current turbofans due to less a high SFC and diameter and weight reductions from counterrotating configurations. Substantial materials properties improvements, along with new fuels, are needed to satisfy the requirements for future supersonic (up to Mach 4.0) aircraft. Hypersonic vehicles will need acceleration more than cruise, combined cycle, variable thrust operation, and reusability. A database is now being accumulated on relevant past efforts as a prelude to studies of hypersonic vehicle propulsion systems. M.S.K.

**A86-36741**
**CALCULATION OF THE STEADY-STATE TRANSVERSE VIBRATIONS OF THE SYSTEM ROTORS-HOUSING OF A GAS-TURBINE ENGINE [K RASCHETU USTANOVIVSHIKHSIA POPERECHNYKH KOLEBANII SISTEM ROTORY-KORPUS GTD]**
L. E. LASTOVETSKII Raschety na Prochnost', no. 26, 1985, p. 209-214. In Russian. refs

A new approach to solving the vibration problem for systems of the type rotors-housing, containing in the general case nonlinearly elastic constraints, is proposed in the context of the theory of vibrations for systems with a finite number of degrees of freedom. It is shown that an exact steady-state solution can be obtained for axisymmetric and quasi-axisymmetric systems without imposing substantial constraints on the initial system as in the existing approaches. V.L.

**A86-37079*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**SURVEY OF SUPERSONIC COMBUSTION RAMJET RESEARCH AT LANGLEY**
G. B. NORTHAM and G. Y. ANDERSON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 27 p. refs
(AIAA PAPER 86-0159)

The Hypersonic Propulsion Branch at NASA Langley Research Center has maintained an active research program in supersonic combustion ramjet (scramjet) and high speed ramjet propulsion since the 1960s. The focus for this research has centered on propulsion for manned reuseable vehicles with cryogenic hydrogen fuel. This paper presents some highlights of this research. The design philosophy of the Langley fixed-geometry airframe-integrated modular scramjet is discussed. The component development and research programs that have supported the successful demonstration of the engine concept using subscale engine module hardware is reviewed and a brief summary of the engine tests presented. An extensive bibliography of research supported by the Langley program is also included. Author

**A86-37096**
**FRONT-LINE POWER**
J. MOXON Flight International (ISSN 0015-3710), vol. 129, April 12, 1986, p. 22-26.

The types of fighter aircraft engines manufactured by western nations are described, along with developmental goals to meet the requirements of new generations of fighter aircraft. In all cases government orders are the sole accounts of the manufacturers. Development is usually paid for by the government(s) ordering the engines. The F100, F110 and F404 engines are the only engines for the F-14, -15, -16, and -18 aircraft, with the government frequently encouraging competition for replacement engines from General Electric (GE) and Pratt and Whitney (PW), the only domestic suppliers. In Europe, SNECMA is frequently the only supplier for the Mirage 2000 engine. Rolls Royce, the only other European manufacturer, produces the RB.199, Mk 104 and Mk 103 engines for use in the Toronado. GE and PW are both developing Increased Performance Engines (IPE) for the USAF. The IPEs are expected to be installed in aircraft in 1990. The Joint Advanced Fighter Engine (Jafe), to produce 30,000-35,000 lb. thrust, 75 percent without afterburner, is requiring research on reducing the IR signature and employing composite parts. European engines under development are the XG-40, the M88, the M53, and the European Fighter Engine (EFA). Prime requirements for new engines for the USAF are substantially increased availability and increased performance. M.S.K.

**N86-24692#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**PROPULSION AND ENERGETICS PANEL WORKING GROUP 14 ON SUITABLE AVERAGING TECHNIQUES IN NON-UNIFORM INTERNAL FLOWS [PANEL DE PROPULSION ET D'ENERGETIQUE GROUPE DE TRAVAIL 14 METHODES D'ESTABLISSEMENT DE CARACTERISTIQUES MOYENNES DANS LES ECOULEMENTS INTERNES HETEROGENES]**
M. PIANKO, ed. and F. WAZELT, ed. (Technische Hochschule, Darmstadt, West Germany) Loughton, England Aug. 1983 183 p refs In FRENCH; ENGLISH summary
(AD-A133968; AGARD-AR-182(FR); ISBN-92-835-2110-2) Avail: NTIS HC A09/MF A01 CSCL 21E

The averaging techniques used for nonuniform internal flow of gas turbine systems, in which the actual flows are usually heterogeneous and three-dimensional was studied. The test analysis and performance prediction methods are based upon simple one-dimensional models. Current practices were reviewed and a theoretical analysis of the relations which may be correctly applied to steady flow was undertaken and known averaging methods were classified. Refinements to known methods and a new approach to averaging for use with engine components and propulsion system analysis are proposed. A variety of possible averaging techniques are identified and compared by preparing a number of sample calculations in ducted flows, turbojet components and a complete propulsion system. The merits and the limitations of the methods studied are outlined. One method is recommended for stagnation temperature averaging. E.A.K.

**N66-24694*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**LOW-SPEED PERFORMANCE OF AN AXISYMMETRIC, MIXED-COMPRESSION, SUPERSONIC INLET WITH AUXILIARY INLETS**
C. J. TREFNY and J. W. WASSERBAUER Feb. 1986 63 p refs
(NASA-TP-2557; E-2771; NAS 1.60:2557) Avail: NTIS HC A04/MF A01 CSCL 21E

A test program was conducted to determine the aerodynamic performance and acoustic characteristics associated with the low-speed operation of a supersonic, axisymmetric, mixed-compression inlet with auxiliary inlets. Blow-in-auxiliary doors were installed on the NASA Ames P inlet. One door per quadrant was located on the cowl in the subsonic diffuser selection of the inlet. Auxiliary inlets with areas of 20 and 40 percent of the inlet capture area were tested statically and at free-stream Mach numbers of 0.1 and 0.2. The effects of boundary layer bleed inflow were investigated. A JT8D fan simulator driven by compressed air was used to pump inlet flow and to provide a characteristic noise signature. Baseline data were obtained at static free-stream conditions with the sharp P-inlet cowl lip replaced by a blunt lip. Auxiliary inlets increased overall total pressure recovery of the order of 10 percent. Author

**N86-24695*#** Beech Aircraft Corp., Wichita, Kans.
**EVALUATION OF PROPFAN PROPULSION APPLIED TO GENERAL AVIATION**
R. W. AWKER Mar. 1966 146 p refs
(Contract NAS3-24349)
(NASA-CR-175020; NAS 1.26:175020) Avail: NTIS HC A07/MF A01 CSCL 21E

Propfan propulsion on business aircraft was evaluated. Comparisons, in terms of cost and performance, were made between propfan propulsion systems and conventional turbofan propulsion systems on a typical business aircraft. In addition, configuration and cost sensitivity studies were conducted to further assess the potential of propfan propulsion. Author

**N86-24696#** Federal Aviation Administration, Washington, D.C.
**EVALUATING TURBINE ENGINE OPERATING CHARACTERISTICS**
19 Mar. 1986 10 p
(FAA-AC-25.939-1) Avail: NTIS HC A02/MF A01

Guidelines for the evaluation of turbine engine (turbojet, turboprop, and turboshaft) operating characteristics for subsonic transport category aircraft are provided. The guidelines describe a method of demonstrating compliance with the applicable airworthiness requirements. Like all advisory circular material, these guidelines are not mandatory and do not constitute a regulation. Derived from Federal Aviation Administration experience in establishing compliance with the airworthiness requirements, they represent the means and methods found to be acceptable to all aircraft designs. Each design should be examined to determine whether the suggested methods of evaluation are adequate or if other methods in addition to these may be appropriate. Author

**N86-24697*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**A REAL-TIME SIMULATION EVALUATION OF AN ADVANCED DETECTION. ISOLATION AND ACCOMMODATION ALGORITHM FOR SENSOR FAILURES IN TURBINE ENGINES**
W. C. MERRILL and J. C. DELAAT 1986 17 p refs Presented at the American Control Conference, Seattle, Wash., 18-20 Jun. 1986; sponsored by IEEE
(NASA-TM-87289; E-2995; NAS 1.15:87289) Avail: NTIS HC A02/MF A01 CSCL 21E

An advanced sensor failure detection, isolation, and accommodation (ADIA) algorithm has been developed for use with an aircraft turbofan engine control system. In a previous paper the authors described the ADIA algorithm and its real-time implementation. Subsequent improvements made to the algorithm and implementation are discussed, and the results of an evaluation presented. The evaluation used a real-time, hybrid computer simulation of an F100 turbofan engine. Author

**N86-24698** Department of the Air Force, Washington, D.C.
**ONE-PIECE HPTR BLADE SQUEALER TIP Patent**
R. L. HORVATH, inventor (to Air Force) 10 Sep. 1985 4 p
(AD-D012003; US-PATENT-4,540,339;
US-PATENT-APPL-SN-616380; US-PATENT-CLASS-416-92)
Avail: US Patent and Trademark Office CSCL 21E

An improved high pressure turbine rotor blade and tip cap structure is provided which comprises a tip end closure for the blade bonded to the end wall of the blade casting. It includes a base plate member and a pair of upstanding side walls defining a peripheral contour coincidental with and faired to the cambered side walls of the casting. The base plate member has a plurality of radially outwardly opening passageways through it and disposed along the chord of the blade and communicating with a channel included in the radially outwardly facing surface of the casting along a chord of the blade. The passageways are disposed along axes at angles to the base plate whereby coolant fluid flowing through it is directed against the tip side wall surfaces. An opening is provided through the end wall of the casting in the form of a slit or a plurality of holes along the chord of the blade and intersecting the channel, to define an outlet through the end wall for passage of coolant fluid through the blade. GRA

**N86-25342*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**DIGITAL ELECTRONIC ENGINE CONTROL (DEEC) FLIGHT EVALUATION IN AN F-15 AIRPLANE**
Mar. 1984 243 p refs Symposium held in Edwards, Calif., 25-26 May 1983
(NASA-CP-2298; H-1201; NAS 1.55:2298) Avail: NTIS HC A11/MF A01 CSCL 21E

Flight evaluation in an F-15 aircraft by digital electronic engine control (DEEC) was investigated. Topics discussed include: system description, F100 engine tests, effects of inlet distortion on static pressure probe, flight tests, digital electronic engine control fault detection and accommodation flight evaluation, flight evaluation of a hydromechanical backup control, augmentor transient capability of an F100 engine, investigation of nozzle instability, real time in flight thrust calculation, and control technology for future aircraft propulsion systems. It is shown that the DEEC system is a powerful and flexible controller for the F100 engine.

**N86-25343*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**DIGITAL ELECTRONIC ENGINE CONTROL F-15 OVERVIEW**
B. KOCK *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 1-14 Mar. 1984
(PAPER-1) Avail: NTIS HC A11/MF A01 CSCL 21E

A flight test evaluation of the digital elctronic engine control (DEEC) system was conducted. An overview of the flight program is presented. The roles of the participating parties, the system, and the flight program objectives are described. The test program approach is discussed, and the engine performance benefits are summarized. A description of the follow-on programs is included. Author

**N86-25344*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**DIGITAL ELECTRONIC ENGINE CONTROL HISTORY**
T. W. PUTNAM *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 15-31 Mar. 1984
(PAPER-2) Avail: NTIS HC A11/MF A01 CSCL 21E

Full authority digital electronic engine controls (DEECs) were studied, developed, and ground tested because of projected benefits in operability, improved performance, reduced maintenance, improved reliability, and lower life cycle costs. The issues of operability and improved performance, however, are assessed in a flight test program. The DEEC on a F100 engine in an F-15 aircraft was demonstrated and evaluated. The events leading to the flight test program are chronicled and important management and technical results are identified. Author

**N86-25345*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**F-15 DIGITAL ELECTRONIC ENGINE CONTROL SYSTEM DESCRIPTION**
L. P. MYERS *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 33-53 Mar. 1984
(PAPER-3) Avail: NTIS HC A11/MF A01 CSCL 21E

A digital electronic engine control (DEEC) was developed for use on the F100-PW-100 turbofan engine. This control system has full authority control, capable of moving all the controlled variables over their full ranges. The digital computational electronics and fault detection and accomodation logic maintains safe engine operation. A hydromechanical backup control (BUC) is an integral part of the fuel metering unit and provides gas generator control at a reduced performance level in the event of an electronics failure. The DEEC's features, hardware, and major logic diagrams are described. Author

**N86-25346*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**NASA LEWIS F100 ENGINE TESTING**
R. A. WERNER, R. G. WILLOH, JR., and M. ABDELWAHAB *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 55-71 Mar. 1984 refs
(PAPER-4) Avail: NTIS HC A11/MF A01 CSCL 21E

Two builds of an F100 engine model derivative (EMD) engine were evaluated for improvements in engine components and digital electronic engine control (DEEC) logic. Two DEEC flight logics were verified throughout the flight envelope in support of flight clearance for the F100 engine model derivative program (EMPD). A nozzle instability and a faster augmentor transient capability was investigated in support of the F-15 DEEC flight program. Off schedule coupled system mode fan flutter, DEEC nose-boom pressure correlation, DEEC station six pressure comparison, and

a new fan inlet variable vane (CIVV) schedule are identified.
Author

**N86-25347*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**EFFECTS OF INLET DISTORTION ON A STATIC PRESSURE PROBE MOUNTED ON THE ENGINE HUB IN AN F-15 AIRPLANE**
D. L. HUGHES and K. G. MACKALL *In its* Digital Electronic Engine Control Flight Evaluation in an F-15 Airplane p 73-89 Mar. 1984 refs
(PAPER-5) Avail: NTIS HC A11/MF A01 CSCL 21E

Problems encountered in obtaining good engine face pressure data were studied. A single static measurement located upstream of the engine hub in the stream flow was found to provide a pressure signal suitable for engine control. Two identical probes for measuring fan inlet static (PS2) pressure were designed and mounted on the hub of the left F100-PW-100 turbofan engine installed in the F-15 test aircraft for flight evaluation. The probe is used as a static pressure sensor for a digital engine control system.
Author

**N86-25348*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**FLIGHT TESTING THE DIGITAL ELECTRONIC ENGINE CONTROL IN THE F-15 AIRPLANE**
L. P. MYERS *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 91-105 Mar. 1984
(PAPER-6) Avail: NTIS HC A11/MF A01 CSCL 21E

The digital electronic engine control (DEEC) is a full-authority digital engine control developed for the F100-PW-100 turbofan engine which was flight tested on an F-15 aircraft. The DEEC hardware and software throughout the F-15 flight envelope was evaluated. Real-time data reduction and data display systems were implemented. New test techniques and stronger coordination between the propulsion test engineer and pilot were developed which produced efficient use of test time, reduced pilot work load, and greatly improved quality data. The engine pressure ratio (EPR) control mode is demonstrated. It is found that the nonaugmented throttle transients and engine performance are satisfactory.
Author

**N86-25349*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**DIGITAL ELECTRONIC ENGINE CONTROL FAULT DETECTION AND ACCOMMODATION FLIGHT EVALUATION**
J. L. BAER-RUEDHART *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in n F-15 Airplane p 107-126 Mar. 1984
(PAPER-7) Avail: NTIS HC A11/MF A01 CSCL 21E

The capabilities and performance of various fault detection and accommodation (FDA) schemes in existing and projected engine control systems were investigated. Flight tests of the digital electronic engine control (DEEC) in an F-15 aircraft show discrepancies between flight results and predictions based on simulation and altitude testing. The FDA methodology and logic in the DEEC system, and the results of the flight failures which occurred to date are described.
E.A.K.

**N86-25350*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**AIRSTART PERFORMANCE OF A DIGITAL ELECTRONIC ENGINE CONTROL SYSTEM ON AN F100 ENGINE**
F. W. BURCHAM, JR. *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 127-139 Mar. 1984
(PAPER-8) Avail: NTIS HC A11/MF A01 CSCL 21E

The digital electronic engine control (DEEC) system installed on an F100 engine in an F-15 aircraft was tested. The DEEC system incorporates a closed-loop air start feature in which the fuel flow is modulated to achieve the desired rate of compressor acceleration. With this logic the DEEC equipped F100 engine can achieve air starts over a larger envelope. The DEEC air start logic, the test program conducted on the F-15, and its results are described.
Author

**N86-25351*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**FLIGHT EVALUATION OF A HYDROMECHANICAL BACKUP CONTROL FOR THE DIGITAL ELECTRONIC ENGINE CONTROL SYSTEM IN AN F100 ENGINE**
K. R. WALSH and F. W. BURCHAM *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 141-155 Mar. 1984
(PAPER-9) Avail: NTIS HC A11/MF A01 CSCL 21E

The backup control (BUC) features, the operation of the BUC system, the BUC control logic, and the BUC flight test results are described. The flight test results include: (1) transfers to the BUC at military and maximum power settings; (2) a military power acceleration showing comparisons bvetween flight and simulation for BUC and primary modes; (3) steady-state idle power showing idle compressor speeds at different flight conditions; and (4) idle-to-military power BUC transients showing where compressor stalls occurred for different ramp rates and idle speeds. All the BUC transfers which occur during the DEEC flight program are initiated by the pilot. Automatic transfers to the BUC do not occur.
Author

**N86-25352*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**BACKUP CONTROL AIRSTART PERFORMANCE ON A DIGITAL ELECTRONIC ENGINE CONTROL-EQUIPPED F100-ENGINE**
J. B. JOHNSON *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 157-170 Mar. 1984 refs
(PAPER-10) Avail: NTIS HC A11/MF A01 CSCL 21E

The air start capability of a backup control (BUC) was tested for a digital electronic engine control (DEEC) equipped F100 engine, which was installed in an F-15 aircraft. Two air start schedules were tested. Using the group 1 start schedule, based on a 40 sec timer, an air speed of 300 knots was required to ensure successful 40 and 25% BUC mode spooldown airstarts. If core rotor speed (N2) was less than 40% a stall would occur when the start bleed closed, 40 sec after initiation of the air start. All jet fuel starter (JFS) assisted air starts were successful with the group 1 start schedule. For the group 2 schedule, the time between pressurization and start bleed closure ranged between 50 sec and 72 sec. Idle rps was lower than the desired 65% for air starts at higher altitudes and lower air speeds.
Author

**N86-25353*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**AUGMENTOR TRANSIENT CAPABILITY OF AN F100 ENGINE EQUIPPED WITH A DIGITAL ELECTRONIC ENGINE CONTROL**
F. W. BURCHAM, JR. and G. D. PAI *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 171-199 Mar. 1984
(PAPER-11) Avail: NTIS HC A11/MF A01 CSCL 21E

An F100 augmented turbofan engine equipped with digital electronic engine control (DEEC) system was evaluated. The engine was equipped with a specially modified augmentor to provide improved steady state and transient augmentor capability. The combination of the DEEC and the modified augmentor was evaluated in sea level and altitude facility tests and then in four different flight phases in an F-15 aircraft. The augmentor configuration, logic, and test results are presented.
Author

**N86-25354*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**INVESTIGATION OF A NOZZLE INSTABILITY ON AN F100 ENGINE EQUIPPED WITH A DIGITAL ELECTRONIC ENGINE CONTROL**
F. W. BURCHAM, JR. and J. R. ZELLER (NASA, Lewis Research Center, Cleveland, Ohio) *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 201-214 Mar. 1984
(PAPER-12) Avail: NTIS HC A11/MF A01 CSCL 21E

An instability in the nozzle of the F100 engine, equipped with a digital electronic engine control (DEEC), was observed during a flight evaluation on an F-15 aircraft. The instability occurred in the upper left hand corner (ULMC) of the flight envelope during augmentation. The instability was not predicted by stability analysis, closed-loop simulations of the the engine, or altitude testing of the engine. The instability caused stalls and augmentor blowouts. The nozzle instability and the altitude testing are described. Linear analysis and nonlinear digital simulation test results are presented. Software modifications on further flight test are discussed.
Author

**N86-25355*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**REAL-TIME IN-FLIGHT THRUST CALCULATION ON A DIGITAL ELECTRONIC ENGINE CONTROL-EQUIPPED F100 ENGINE IN AN F-15 AIRPLANE**
R. J. RAY (California Polytechnic State Univ., San Luis Obispo) and L. P. MYERS *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 231-247 Mar. 1984
(PAPER-13) Avail: NTIS HC A11/MF A01 CSCL 21E

Computer algorithms which calculate in-flight engine and aircraft performance real-time are discussed. The first step was completed with the implementation of a real-time thrust calculation program on a digital electronic engine control (DEEC) equiped F100 engine in an F-15 aircraft. The in-flight thrust modifications that allow calculations to be performed in real-time, to compare results to predictions, are presented. Author

**N86-25356*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**CONTROL TECHNOLOGY FOR FUTURE AIRCRAFT PROPULSION SYSTEMS**
J. R. ZELLER, J. R. SZUCH, W. C. MERRILL, B. LEHTINEN, and J. F. SOEDER *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 231-247 Mar. 1984
(PAPER-14) Avail: NTIS HC A11/MF A01 CSCL 21E

The need for a more sophisticated engine control system is discussed. The improvements in better thrust-to-weight ratios demand the manipulation of more control inputs. New technological solutions to the engine control problem are practiced. The digital electronic engine control (DEEC) system is a step in the evolution to digital electronic engine control. Technology issues are addressed to ensure a growth in confidence in sophisticated electronic controls for aircraft turbine engines. The need of a control system architecture which permits propulsion controls to be functionally integrated with other aircraft systems is established. Areas of technology studied include: (1) control design methodology; (2) improved modeling and simulation methods; and (3) implementation technologies. Objectives, results and future thrusts are summarized.
E.A.K.

**N86-25360#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
**DAMAGE TOLERANCE CONCEPTS FOR CRITICAL ENGINE COMPONENTS**
Loughton, England Oct. 1985 295 p refs Presented in San Antonio, Tex., 22-26 Apr. 1985
(AGARD-CP-393; ISBN-92-835-0380-5) Avail: NTIS HC A13/MF A01

The proceedings of a specialist meeting called by the AGARD Structures and Materials Panel on damage tolerance concepts for critical engine components is presented. The meeting discussed the overall philosophy of damage tolerance as applied to aircraft engine parts, considered and refined the parameters important in DTC, reviewed specialist techniques needed for the support of DTC, and surveyed the prospects for and experiences of the implementation of DTC.

**N86-25361#** Rolls-Royce Ltd., Derby (England).
**DAMAGE TOLERANCE CONCEPTS FOR CRITICAL ENGINE COMPONENTS**
R. H. JEAL *In* AGARD Damage Tolerance Concepts for Critical Engine Components 12 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

The cost of failures in gas turbines has always been so high, both in human and financial terms, that it has been recognized since the earliest days that the behavior of components had to be fully characterized before the engines were used in service. The integrity of the gas turbine has therefore always been based upon two separate phases of development. The first has been the basic design itself where, as well as ensuring that the individual components meet their basic mechanical purpose, the designer attempts to match his understanding of the operating conditions to his perception of the capability of material chosen. The second has been the development phase where the actual behavior of the component has been assessed either as part of an operating engine - bench engine testing or as an individual component - rig testing - under conditions which are related to those the engine is expected to see in service. The results of this work are then used, together with prior experience, to identify the critical components of the engine, those that prejudice the safety of the aircraft if they fail. The development of damage tolerance concepts is traced from the earliest days, the current situation is examined in light of design needs and available technology, and possible directions are examined.
E.R.

**N86-25362#** Naval Air Propulsion Test Center, Trenton, N.J. Systems Development and Evaluation Group.
**ENGINE CYCLIC DURABILITY BY ANALYSIS AND TESTING: HIGHLIGHTS OF THE SPRING 1984 PEP MEETING**
A. A. MARTINO *In* AGARD Damage Tolerance Concepts for Critical Engine Components 13 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Research on gas turbine engine development during the past decade in NATO nations has concentrated heavily on gaining better understanding of the relationship between material characteristics, failure mechanisms, structural analysis and validation testing for increased service life. Recognizing this intense interest and activity level the Propulsion and Energetics Panel (PEP) sponsored a specialists' meeting that surveyed the state-of-art technical areas related to improving engine life and considered the technical and economical problems and possibilities of advanced cyclic testing in the development of engines. Discussions focused on relationships between engine use and failure modes, accelerated mission testing (AMT) development, critical material characteristics, component life assessment methods, recent results of component and engine cyclic testing, and future requirements. Author

**N86-25365#** Rolls-Royce Ltd., Derby (England). NDT Technology.
**LIMITATIONS OF MANUAL NDT SYSTEMS AND THE NO EYES CONCEPT**
R. G. TAYLOR *In* AGARD Damage Tolerance Concepts for Critical Engine Components 9 p Oct. 1985 refs Previously announced as N86-14215
Avail: NTIS HC A13/MF A01

Defect tolerant design, particularly of aircraft components, and its links with nondestructive testing (NDT) are discussed. Engineering of the NDT technique, defect detection requirements, and human factors in the inspection cycle are considered.
Author

**N86-25368#** Systems Research Labs., Inc., Dayton, Ohio. NDE Systems Div.

**MANUFACTURING TECHNOLOGY FOR NONDESTRUCTIVE EVALUATION (NDE) SYSTEM TO IMPLEMENT RETIREMENT FOR CAUSE (RFC) PROCEDURES FOR GAS TURBINE ENGINE COMPONENTS**

D. L. BIRX and D. G. DOOLIN *In* AGARD Damage Tolerance Concepts for Critical Engine Components 8 p Oct. 1985 refs

Avail: NTIS HC A13/MF A01

An automated NDE inspection system to detect surface flaws and inclusions in jet engine rotary parts was developed. The system implements the Air Force Retirement for Cause philosophy in which good, used engine parts are returned to service, and flawed components are retired for cause. Emphasis has thus been placed on improving current flaw detection and characterization techniques by using computer algorithms (removing the human decision process) and achieving basic inspection and predictive capabilities via automated eddy current and ultrasonic inspection techniques. Author

**N86-25369#** National Aerospace Lab., Amsterdam (Netherlands).

**AGARD COOPERATIVE TEST PROGAMME ON TITANIUM ALLOY ENGINE DISC MATERIAL**

A. J. A. MOM and M. D. RAIZENNE (National Research Council of Canada, Ottawa, Ontario) *In* AGARD Damage Tolerance Concepts for Critical Engine Components 15 p Oct. 1985 refs

Avail: NTIS HC A13/MF A01

In recent years a strong interest in the application of damage tolerance techniques for lifing of gas turbine engine discs has developed. Before the damage tolerance approach can be safely implemented it requires sensitive and reliable crack detection techniques, operational loading information and improved knowledge of fatigue crack growth and fracture under service conditions. This latter aspect is the main subject of an international test program, in which a number of laboratories from North America and Europe participate under AGARD coordination. The first phase of the program is directed to test and specimen standardization and calibration of the different laboratories. The second phase will specifically address parameters relevant for real service operation like mission loading, sequence and dwell effects, temperature, fatigue threshold, etc. The background and first phase of the program are discussed. Author

**N86-25378#** Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).

**FRACTURE MECHANICS AND LCF-PROPERTIES OF ENGINE DISCS OF TI 6AL-4V, INCONEL 718 AND UDIMET 700 P/M-HIP**

W. SCHUETZ and R. HEIDENREICH *In* AGARD Damage Tolerance Concepts for Critical Engine Components 13 p Oct. 1985 refs

Avail: NTIS HC A13/MF A01

Over the last decade IABG has carried out a large number of tests on gas turbine materials to determine the materials data necessary for the conventional lifing approach, that is LCF data, including dwell time effects and some HCF data. The data necessary for a damage tolerance approach as well as crack propagation properties were also determined. These tests were done at room and typical service temperatures. The materials were Ti 6A1 4V, Inconel 718 and Udimet 700 P/M-HIP. The specimens were machined from a number of nominally identical compressor discs of Ti A16 V4, from compressor discs of Inconel 718 and from disc-shaped 'pancakes' of Udimet 700 P/M-HIP. Constant amplitude tests under strain control with unnotched specimens and under stress control with notched specimens were carried out, as well as a number or relatively simple variable amplitude tests. Author

**N86-25379#** Technische Univ., Munich (West Germany). Materials Lab.

**EVALUATION OF CYCLIC SPIN PIT TESTS FOR THE DAMAGE TOLERANCE OF DISKS**

H. HUFF and G. W. KOENIG *In* AGARD Damage Tolerance Concepts for Critical Engine Components 13 p Oct. 1985 refs

Avail: NTIS HC A13/MF A01

In order to determine the damage tolerance at critical areas of nickelbase engine disks (bore, eccentric hole, blade slot) the crack propagation behavior was investigated. The experiments include cyclic spin pit tests on disks and fracture mechanics tests on small crack specimens. The results of the spin pit tests are compared with the crack propagation behavior predicted by fracture mechanics. The tolerance of engine disks with respect to small crack-like defects is estimated and the potential of the crack propagation life for application in service is discussed. It was found that at low and intermediate temperatures the crack propagation life is sufficient to cover a substantial portion of the life required for disks. With increasing temperature the influence of time dependent processes results in a very strong reduction of the defect tolerance. Author

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-33979#**

**ON THE VERTICAL TURNS SUSTAINING CORNER VELOCITY**

K. KATO (Tokyo, University, Japan) and S. UENO (Toshiba Co., Ltd., Kawasaki, Japan) (Japan Society for Aeronautical and Space Sciences, Annual Conference, 15th, Tokyo, Japan, Apr. 1984) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 28, Feb. 1986, p. 175-184. refs

Minimum time pull-up maneuvers in the vertical plane are formulated and solved numerically as an optimal control problem. Restrictions due to thrust, load factor and angle of attack (or stall) are involved as the inequality constraints. It is shown that the intermediate thrust arc can be optimal and the exact necessary conditions are derived with the maximum-turn-rates sustained. A variety of the optimal pull-ups are also shown when the initial velocity is varied. Author

**A86-34193**

**FLYING HANDS OFF TO A HOVER**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 10-15.

Using microprocessors, multifunction CRT displays, and multiplex digital data buses, helicopter electric flight director systems are integrated with digital automatic flight control systems (DAFCS) to enable hands-off flying for IFR certification. Flight management systems (FMS), consolidate information from the communications, navigation, and performance subsystems. The electronic flight instrument system, using the EDZ-705 electronic flight instrument system, displays flight data such as airspeed and altitude on the electronic attitude director indicator (EADI), and data such as heading and bearing on the electronic horizontal situation indicator (EHSI). DAFCS is an integrated autopilot with a full range of horizontal and vertical flight guidance modes, including all radio guidance modes, hover mode, and coupled collective. An ILS approach can be flown, with navigation mode armed to capture the localizer, the ILS mode armed to capture glide slope, and the radio altimeter DH set to IFR minimum altitude. R.R.

**A86-34194**

**GUIDANCE, NAVIGATION, AND CONTROL FOR 21ST CENTURY AIRCRAFT**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 18-24.

Developments such as optical fault-tolerant buses, full digital fly-by-wire control, and active flutter suppression for military aircraft with stores, will make possible ultra fault-tolerant, reliable, high-integrity flight control systems and avionics architectures for the next generation civil and military aircraft. Multiple-redundant automatic flight control systems (AFCS) will enable maximum airframe and engine element performance by relaxing many traditional stability and control constraints. Local flow or vortex control over all lifting surfaces and parts of the fuselage, and integration of highly interactive subsystems like vectored thrust, will improve cruise performance, short field capability, and maneuverability. Other innovations foreseen include automated situational information management systems, the application of artificial intelligence, and local pressure, vibration, surface conditions, and deflection measurement sensors. R.R.

**A86-34926#**

**AN APPLICATION OF SELF-TUNING REGULATOR TO GLA SYSTEM OF AN AIRCRAFT**

M. KOBAYAKAWA, K. SAKURA, and H. IMAI (Setsunan University, Japan) Kyoto University, Faculty of Engineering, Memoirs (ISSN 0023-6063), vol. 48, Jan. 1986, p. 60-74. refs

In this paper, a Self-Tuning Regulator (STR), one of the adaptive control strategies, is applied to the gust load alleviation system of a large civil aircraft. Two types of STR are introduced. For algorithm 1, the restriction that the number of the inputs must be equal to that of the outputs is imposed. On the contrary, for algorithm 2, this restriction is released. These two algorithms are applied to alleviate the gust response of aircrafts, firstly a rigid aircraft and secondly a flexible one. In consequence of simulations, it is found that the STR can alleviate the gust response of aircrafts favorably. A STR is more effective to alleviate response to a discrete gust than to a continuous gust. In spite of the inaccurate estimation of system parameters, the STR works well. Generally, the proposed STRs show better performance for a rigid aircraft than for a flexible one. However, even for the latter, by choosing initial values of parameters appropriately, good results can be obtained. Author

**A86-35153#**

**ROLL-DAMPING MEASUREMENTS ON TWO FLIGHT BODY CONFIGURATIONS IN THE GOETTINGEN DFVLR-AVA TRANSONIC WIND TUNNEL [ROLLDAEMPFUNGSMESSUNGEN AN ZWEI FLUGKOERPER-KONFIGURATIONEN IM TRANSKANAL DER DFVLR-AVA GOETTINGEN]**

E. SCHMIDT (DFVLR, Aerodynamische Versuchsanstalt, Goettingen, West Germany) and H.-G. FUCHS (Dornier GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 41 p. In German. refs
(DGLR PAPER 85-090)

Measurements carried out in the DFVLR-AVA transonic wind tunnel in Goettingen on flight body configurations using two new rolling components are discussed. Coefficients and derivatives of the rolling motion are used to obtain plots of the measured angles of attack as a function of Mach number and reduced frequency. The results are compared with those from a half-empirical procedure. C.D.

**A86-35177#**

**LMR-83 - INERTIAL MEASUREMENT UNIT FOR FLIGHT REGULATION AND NAVIGATION [LMR-83 - EINE INERTIALE MESSEINHEIT FUER FLUGREGELUNG UND NAVIGATION]**

G. SCHULZ (Litton Technische Werke Freiburg im Breisgau, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 14 p. In German. refs
(DGLR PAPER 85-132)

Based on the measurement data requirements of future high-performance aircraft, the design, operation, and output results of the inertial measurement unit LMR-85 are described. The quadruplex usage of this measurement device in a fly-by-wire aircraft is discussed. Modifications in this device made with regard to avionics systems considerations in high-performance aircraft are addressed. C.d.

**A86-35342**

**NEW LINEAR TRACKING FILTERS**

D. ANDRISANI, II (Purdue University, West Lafayette, IN) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 175-178. refs

A description is provided of linear tracking filters with superior ability to track maneuvering aircraft. The filters model both the vehicle rotation and translation degrees of freedom, and compute both the magnitude and direction of the vehicle acceleration. The estimation of attitude improves the filter's ability to estimate position and velocity, as a result of the correlation between aircraft acceleration and attitude. Some linearizing assumptions are needed on account of the nonlinearity of the relationship between attitude and acceleration. Attention is given to a mathematical model for the pitch rotation degree of freedom, the state equation model for vertical translation and pitch rotation, and the tracker model. G.R.

**A86-35360*** Minnesota Univ., Minneapolis.

**APPLICATION OF EIGENSPACE TECHNIQUES TO DESIGN OF AIRCRAFT CONTROL SYSTEMS**

B. S. LIEBST and W. L. GARRARD (Minnesota, University, Minneapolis) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 475-480. refs
(Contract NAG1-217)

Eigenspace techniques allow the control system designer to use feedback to place eigenvalues and shape eigenvectors so as to modify closed loop dynamic response characteristics to achieve performance objectives. In this paper the theory of eigenspace design is reviewed, extended and applied to several aircraft control problems. Author

**A86-35370**

**ADAPTIVE FLUTTER SUPPRESSION IN THE PRESENCE OF TURBULENCE**

A. CHAKRAVARTY, D. GANGSAAS (Boeing Co., Seattle, WA), and J. B. MOORE (Australian National University, Canberra, Australia) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 751-756.

This paper presents an application of adaptive control to flutter suppression for an aircraft flying in turbulence. The adaptive control law is integrated with a nominal constant gain controller and furnishes the equivalent of a 180 deg phase margin at the flutter frequency. The design approach blends the classical, linear quadratic Gaussian and adaptive synthesis techniques, so that each contributes at its point of strength to achieve a robust control law with good performance characteristics. It is shown that the adaptive controller stabilizes the flutter in the face of arbitrary initial parameter estimates, unmodeled stochastic inputs, and significant level of spillover dynamics. Author

**A86-35383**

**TIME DOMAIN CONTROL DESIGN FOR ROBUST STABILITY OF LINEAR REGULATORS - APPLICATION TO AIRCRAFT CONTROL**

R. K. YEDAVALLI (Stevens Institute of Technology, Hoboken, NJ) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 914-919. refs

This paper addresses the aspect of 'Stability Robustness' of linear systems in time domain. Upper bounds on the linear perturbation of an asymptotically stable linear system are obtained to maintain stability, both for 'structured' as well as 'unstructured' perturbations using Liapunov approach. A quantitative measure called 'Stability Robustness Index' is introduced and this measure is used to design 'robust' controllers for Linear Quadratic (LQ) Regulators. The proposed control design algorithm can be used, for given set of perturbations, to select the range of control effort for which the system is stability robust. Conversely it can also be used, for given control effort, to determine the range of the size of allowable perturbations. The algorithm is illustrated with the help of an aircraft control example. The scope of the proposed research and its extension to LQG Regulators, dynamic compensator design and other applications are discussed. Author

**A86-35384**

### COORDINATED BANK-TO-TURN AUTOPILOT DESIGN

C.-F. LIN (Boeing Co., Seattle, WA) and W. R. YUEH (Northrop Corp., Electronics Div., Hawthorne, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 922-926. refs

Bank-to-turn (BTT) missile coordinated autopilot system design principle is presented. The general design concept, design objective and requirement, design approach, and performance analysis are discussed. The closed loop system of the resulting control law is stable for a wide range of flight conditions with little changes in the location of the closed loop eigenvalues. The control loop frequency responses of six flight conditions during the terminal phase are presented to show the robustness of a feedback controller design. Simulations of the time responses of the tracking system are also presented to demonstrate tracking autopilot with good turn coordination. Author

A86-35404* Integrated Systems, Inc., Palo Alto, Calif.

### FLIGHT TEST TRAJECTORY CONTROLLER SYNTHESIS WITH CONSTRAINED EIGENSTRUCTURE ASSIGNMENT

P. K. A. MENON, H. A. SABERI, R. A. WALKER (Integrated Systems, Inc., Palo Alto, CA), and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1181-1186. refs

(Contract NAS2-11877)

The design of a maneuver autopilot for flight test trajectory control using constrained eigenvalue/eigenvector assignment is examined. The aircraft considered was a high-performance fighter with a command augmentation system engaged in all three axes. Attention is given to difficulties encountered in the generation of the desired eigenvalues and eigenvectors. It is found that this approach demands several iterations to converge to a satisfactory result, and does not appear to easily yield suitable insight for the output feedback design of high-order multivariable systems which will be used at other operating points. It is concluded that this technique could be made more attractive by generating gradients of the eigensystem between flight conditions, and including this information in the single-point design technique. B.J.

**A86-35443**

### PILOT INTERFACE WITH FLY-BY-WIRE CONTROL SYSTEMS

W. W. MELVIN (Air Line Pilots Association International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 153-157. refs

(SAE PAPER 851836)

The problems of pilot interface with automatic fly-by-wire control systems are described. The differences between manual and automatic aircraft control are examined. The incorporation of stability augmentation systems with fly-by-wire automatic systems to enhance the stability of the aircraft is discussed. I.F.

**A86-35457**

### SR-71 DIGITAL AUTOMATIC FLIGHT AND INLET CONTROL SYSTEM

R. P. DEGREY, R. L. NELSON, and J. E. MEYER (Lockheed Corp., Burbank, CA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 399-410.

(SAE PAPER 851977)

This paper presents a description and treats the integration of a new triple channel multi-rate Digital Automatic Flight and Inlet Control System (DAFICS) into the SR-71 aircraft. Predicted airframe longevity to the year 2000 and aging automatic flight control/air inlet control analog systems dictated a modernization program to insure supportability over the life span of the aircraft. Aerodynamic consideration and development rationale is provided. A functional system description identifies the systems being replaced. Simulation, hardware/software development, redundancy management and flight experience is presented. Finally, digital and analog control comparisons are made and improvements discussed. Author

**A86-35563#**

### FRONT SEAT ON THE FUTURE

B. ZIEGLER (Airbus Industrie, Blagnac, France) Aerospace America (ISSN 0740-722X), vol. 24, April 1986, p. 66-68, 70.

Design and performance features of the Airbus 320 cockpit and control systems are outlined. The aircraft, designed to be almost completely computer-controlled with no single-failure flight critical systems, is to always maintain a minimum pitch roll control. The conventional control surfaces will have a mix of electrical and hydraulic actuators, the mechanical systems being largely emergency back-ups. There will be no mechanical linkage between the cockpit and the control mechanisms. The conventional configuration wil provide a neutral static stability which aids the limited back-up control mechanisms. The various techniques being incorporated into the flight control system to enhance instructor-student interactions and permit pilot-first officer interactive control of the aircraft in low-altitude turbulent flight regimes are described. One innovative feature of the automated control system is the provision of a wind shear modes to compensate for pilot errors. M.S.K.

**A86-35602**

### HIGHER HARMONIC CONTROL - WIND TUNNEL DEMONSTRATION OF FULLY EFFECTIVE VIBRATORY HUB FORCE SUPPRESSION

J. SHAW, N. ALBION, E. J. HANKER, JR., and R. S. TEAL (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 1-15. refs

A dynamically scaled model of the three-bladed CH-47D helicopter rotor has successfully demonstrated closed loop Higher Harmonic Control (HHC) in wind tunnel tests, simultaneously suppressing vertical and in-plane 3/rev hub forces throughout the test envelope. HHC has accomplished this level of suppression by means of a fixed gain feedback control law that is simpler and faster than the adaptive control laws recently employed by others. The controller applied small amounts of oscillatory swashplate motion in order to generate multiharmonic blade pitch variations of up to + or - 3 deg at very high speed. O.C.

**A86-35604*** Massachusetts Inst. of Tech., Cambridge.

**HELICOPTER GUST ALLEVIATION, ATTITUDE STABILIZATION, AND VIBRATION ALLEVIATION USING INDIVIDUAL-BLADE-CONTROL THROUGH A CONVENTIONAL SWASH PLATE**

N. D. HAM (MIT, Cambridge, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 33-45. NASA-sponsored research. refs

The novel active control system presented for helicopter rotor aerodynamic and aeroelastic problems involves the individual control of each blade in the rotating frame over a wide range of frequencies (up to the sixth harmonic of rotor speed). This Individual Blade Control (IBC) system controls blade pitch by means of broadband electrohydraulic actuators attached to the swash plate (in the case of three blades) or individually to each blade, using accelerometer signals to furnish control commands to the actuators. Attention is given to IBC's application to blade lag, flapping, and bending dynamics. It is shown that gust alleviation, attitude stabilization, vibration alleviation, and air/ground resonance suppression, are all achievable with a conventional helicopter swash plate. O.C.

**A86-35622*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DIRECTIONAL HANDLING QUALITIES REQUIREMENTS FOR NAP OF THE EARTH (NOE) TASKS**

C. C. BIVENS (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 297-314. refs

A piloted simulator experiment has been conducted to ascertain the directional axis handling requirements of hover and below 40-kt tasks of a scout/attack helicopter, with attention to such light helicopter configurations as those being considered for the 'LHX' program. Two types of yaw stability and control augmentation system were implemented: one consisted of a washed-out yaw rate feedback and shaped control unit, while the other involved a yaw rate command heading-hold system. Experiment results indicate that rotorcraft configurations with high directional gust sensitivity require greater minimum yaw damping to maintain satisfactory handling qualities in nap of the earth flight. Yaw damping and control response are critical handling qualities parameters in air-to-air target acquisition and tracking. O.C.

**A86-35623**

**ASSESSMENT OF ROTORCRAFT AGILITY AND MANEUVERABILITY WITH A PILOT-IN-THE-LOOP SIMULATION**

L. S. LEVINE, F. W. WARBURTON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), and H. C. CURTISS, JR. (Princeton University, NJ) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 315-325.

Attention is given to an economical, minicomputer-based, six-degree-of-freedom piloted simulation for assessing the effect of rotorcraft design parameters on combat effectiveness. A pilot-directed vehicle is used whose agility and maneuverability characteristics can be varied for different flights against a computer-driven adversary. The effects of roll time constant, sideslip envelope, and auxiliary propulsion system are investigated for two combat scenarios employing forward firing guns; effectiveness is quantified in terms of the probabilities of target kill and of survival over combat time. The results obtained provide insight into the relationship between vehicle handling qualities and weapons pointing tasks during maneuvering flight. O.C.

**A86-35625**

**HELICOPTER HANDLING REQUIREMENTS BASED ON ANALYSIS OF FLIGHT MANEUVERS**

R. K. HEFFLEY and S. M. BOURNE (Manudyne Systems, Inc., Los Altos, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 339-344. refs

An approach is described for the direct examination of helicopter flight maneuvers in order to determine handling qualities requirements. A general procedure is outlined for relating closed-loop discrete maneuver performance features to conventional open-loop vehicle characteristics. Two of the main maneuver features analyzed are the maneuver aggressiveness and maneuver amplitude. Flight data results from a variety of roll-axis maneuvers are presented. It can be seen that maneuver aggressiveness is highest for low-amplitude maneuvers and, because of an apparent upper bound on peak roll rate, lessens for larger-amplitude commands. Author

**A86-35626**

**A COMPARATIVE STUDY OF AN ARTICULATED INTEGRATED SIDE-ARM CONTROLLER IN A VARIABLE STABILITY HELICOPTER**

J. M. MORGAN (National Aeronautical Establishment, Flight Research Laboratory, Ottawa, Canada) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 359-366. refs

A large amplitude displacement four degrees of freedom manipulator was flown in a piloted experiment as a fully integrated side-arm controller (SAC) in the NAE Airborne Simulator. The experimental tasks were flown by four evaluation pilots using (1) conventional helicopter controls, (2) the SAC configured with a spherical grip and (3) the SAC configured with a conformal vertically oriented grip. Cooper Harper data for a series of tasks at and around the hover suggest that the grip configured controller degrades the vehicle by approximately one half of a Cooper Harper point, but that the spherical interface leads to approximately 1.5 points degradation. The spherical grip was noted as being more prone to cross-coupling than the conformal grip. Author

**A86-35984**

**LOCALLY OPTIMAL CONTROL IN SYSTEMS WITH DELAY [LOKAL'NO-OPTIMAL'NOE UPRAVLENIE V SISTEMAKH S ZAPAZDYVANIEM]**

G. L. DEGTIAREV and S. A. TERENTEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 39-42. In Russian.

The problem of determining control parameters in flight vehicle stabilization systems with delay is analyzed for the case of incomplete measurements of the state. Optimal control is determined as a function of the current and previous measurements of the system state. The problem is reduced to that of solving a closed system of equations for the unknown parameters. V.L.

**A86-36772#**

**PRELIMINARY DESIGN OF LOW AUTHORITY SAS. I**

T. HACKER (Institute of Aviation, Bucharest, Rumania) and B. TEODORESCU (Bucuresti, Institutul Politehnic, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 30, Nov.-Dec. 1985, p. 565-576.

The early stage of preliminary synthesis is viewed from the flight dynamicist's standpoint. Specific eigenvalue requirements concerning damping, frequency, and initial response are directly mapped into control gain space. Time domain criteria are seen to influence selection of the system structure and the gain values. Problems caused by flight control system/airframe interaction are considered. Modal requirements currently assigned to airframe alone are extended to airframe/flight control system dynamics and feedbacks of airframe states are used to cure flight control system-induced instability. Author

**A86-36871#**
**A COMPUTER CONTROLLED AUTOPILOT AND AN ANNUNCIATION SYSTEM FOR LIGHT AIRCRAFT**
S. N. DWIVEDI (North Carolina, University, Charlotte) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 111-119. refs

A design is described for an integrated autopilot for a light aircraft, that not only flies the airplane but also monitors its systems. In the event of any malfunction, the onboard computer announces the problem and on command follows the remedial procedure. Features of the system include the use of a synthesized voice to prompt the pilot or announce malfunctions and the use of a microcomputer to monitor the aircraft systems. The system incorporates the best features of several existing autopilots and consists of nine different processors for the following functions: system controller, backup, autopilot, navigation, integrated data control, radio adapter unit, electronic horizontal situation indicator, Votrax speech units, and the hand-held computer. D.H.

**A86-37061*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**THE INFLUENCE OF SAMPLING RATE ON THE DYNAMICS AND CONTROL OF AERONAUTICAL SYSTEMS**
J. C. HOWARD and L. D. WEBSTER (NASA, Ames Research Center, Moffett Field, CA) IN: Annual Pittsburgh Conference 16th, University of Pittsburgh, PA, April 25, 26, 1985, Proceedings. Research Triangle Park, NC, Instrument Society of America (Modeling and Simulation. Volume 16, Pt. 5), 1985, p. 1467-1478. refs

It is shown in the design of aeronautical control systems that sampling rate variations give rise to migrations of the discrete eigenvalues for both the plant and the controllers. In general, these migrations tend to degrade simulation fidelity and the overall performance of Ultrareliable Fault Tolerant Control Systems (UFTCS). These systems consist of a redundant asynchronous network of microprocessors which use sensor information to generate the servo commands that drive actuators, thrust linkages, etc. A change in the sampling period of a single microprocessor will, in addition to causing an eigenvalue shift, alter the magnitude of the servo command issued by the controller. The influence of these changes and the effect of initial conditions and skew are considered. Author

**A86-37070*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**ADAPTIVE CONTROL ROBUSTNESS IN FLEXIBLE AIRCRAFT APPLICATION**
E. N. SANCHEZ (NASA, Langley Research Center, Hampton, VA) American Control Conference, Seattle, WA, June 18-20, 1986, Paper. 4 p. refs

This paper presents the application of a model reference adaptive control (MRAC) algorithm to flexible aircraft flight control. The algorithm is an adaptive version of the Command Generator Tracking (CGT) control technique. This technique forces a dynamic system to follow a reduced-order model, allowing it to cope with the problem of unmodeled dynamics. The studies were made via simulation, using for the plant an aircraft dynamic model similar to the B1 bomber. This model is of a large aircraft with a reasonable amount of structural flexibility. In particular, flight configurations were analyzed where the influence of the flexible modes make it difficult to control the aircraft. The results indicate that the algorithm has good robustness properties vis-a-vis unmodeled dynamics and can force the flexible aircraft to follow rigid body responses. Author

**N86-24700*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SWASHPLATE CONTROL SYSTEM Patent Application**
R. J. PEYRAN, inventor (to NASA) (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.), G. H. LAUB, inventor (to NASA) (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.), and H. A. MORSE, inventor (to NASA) (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.) 31 Mar. 1986 13 p
(NASA-CASE-ARC-11633-1; NAS 1.71:ARC-11633-1; US-PATENT-APPL-SN-846439) Avail: NTIS HC A02/MF A01 CSCL 01C

A mechanical system to control the position of a rotating swashplate is developed. This system provides independent lateral cyclic, longitudinal cyclic and collective pitch control of a helicopter rotor attached to the swashplate, without use of a mixer box. The system also provides direct, linear readout of cyclic and collective swashplate positions. A swashplate control system has a first gimbal ring pivotally mounted along a longitudinal axis. A second gimbal ring is pivotally attached to the first gimbal ring along a lateral axis. A longitudinal cyclic actuator pivots the first gimbal ring along the longitudinal axis. A lateral cyclic actuator pivots the second gimbal ring along the lateral axis. The lateral cyclic actuator is mounted on the first gimbal ring. A swashplate is rotatably mounted on the second gimbal ring. Prior swashplate control systems required use of a mixer box to provide true decoupling of lateral and longitudinal cyclic input to the swashplate. Author

**N86-24701#** National Aeronautics and Space Administration, Washington, D.C.
**EIGENSTRUCTURE ASSIGNMENT AND ITS APPLICATION IN DESIGN OF FLIGHT CONTROL SYSTEMS**
Z. GENG and D. FU May 1986 15 p refs Transl. by SCITRAN, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-88411; NAS 1.15:88411) Avail: NTIS HC A02/MF A01 CSCL 01C

The present paper is concerned with an extension of the basic concept and the algorithm of eigenstructure assignment. A general conclusion is drawn regarding the assignment of freedoms in the case of the eigenstructure, taking into account a completely controllable linear time-invariant system. The new algorithms are provided for assigning the eigenstructure with multiple eigenvalues and/or with complex conjugate eigenvalues. The application of the eigenstructure assignment method to the design of a flight control system is illustrated with the aid of a numerical example involving an aircraft flight control system. Author

**N86-24702*#** Georgetown Univ., Washington, D.C. School of Engineering and Applied Science.
**A RESEARCH PROGRAM IN ACTIVE CONTROL/AEROELASTICITY Final Semiannual Status Report, May - Oct. 1985**
Oct. 1985 15 p
(Contract NAG1-199)
(NASA-CR-176773; NAS 1.26:176773) Avail: NTIS HC A02/MF A01 CSCL 01C

In this research period a synthesis methodology for multifunctional robust aeroservoelastic systems was developed. The development consisted of the following stages: (1) development of an universal diagram to determine phase and gain margins of a multi-input multi-output (MIMO) system using singular value based stability margin criteria; (2) determination of singular value gradients with respect to design parameters and their application to improve stability margins of multiloop system; and (3) application of constrained optimization techniques to synthesize a low order robust controller for a high order MIMO aeroservoelastic system while satisfying several design constraints on the dynamic loads and responses and stability margins at the plant input and output. Overall research activities are summarized. Author

**N86-24703*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LATERAL AND LONGITUDINAL AERODYNAMIC STABILITY AND CONTROL PARAMETERS OF THE BASIC VORTEX FLAP RESEARCH AIRCRAFT AS DETERMINED FROM FLIGHT TEST DATA**

W. T. SUIT and J. G. BATTERSON Apr. 1986 38 p
(NASA-TM-87711; NAS 1.15:87711) Avail: NTIS HC A03/MF A01 CSCL 01C

The aerodynamics of the basic F-106B were determined at selected points in the flight envelope. The test aircraft and flight procedures were presented. Aircraft instrumentation and the data system were discussed. The parameter extraction procedure was presented along with a discussion of the test flight results. The results were used to predict the aircraft motions for maneuvers that were not used to determine the vehicle aerodynamics. The control inputs used to maneuver the aircraft to get data for the determination of the aerodynamic parameters were discussed in the flight test procedures. The results from the current flight tests were compared with the results from wind tunnel test of the basic F-106B. B.G.

**N86-24705#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**EXPERIMENTAL STUDY OF APEX FENCES FOR LIFT ENHANCEMENT ON A HIGHLY SWEPT DELTA WING CONFIGURATION M.S. Thesis**

M. STUART Dec. 1985 197 p refs
(AD-A163877; AFIT/GAE/AA/85D-14) Avail: NTIS HC A09/MF A01 CSCL 12A

The longitudinal stability characteristics of a 60 deg. delta wing/body model equipped with various types of apex fences were studied experimentally. The experimental effort used force balance instrumentation and oil flow visualization. The locations of the fence-generated vortices and leading-edge vortices associated with highly swept wings were also determined. Five major fence parameters (shape, surface area, cant, length-to-height, movement) were studied and the results are given in a qualitative analysis. Results indicate a favorable application of apex fences for STOL operations. The fences increase lift and positive pitching moment which dictates the use of trailing edge flaps, further increasing the available maximum lift for takeoff and landing. Accompanying this is a large increase in drag at low angles of attack and a marginal increase at moderate to high angles. The relative strength of nose-down pitching moments at high (above 35 deg.) angles of attack produced by apex fences is slight. Apex fences seem to be a technology whose time may have come. Further research of the lateral behavior of a fenced aircraft appears warranted. GRA

**N86-24706#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**MULTIVARIABLE CONTROL LAW DESIGN FOR ENHANCED AIR COMBAT MANEUVERING. F-15/STOL (SHORT TAKE-OFF AND LANDING) DERIVATIVE FIGHTER M.S. Thesis**

K. A. SHEEHAN Dec. 1985 378 p refs
(AD-A164017; AFIT/GE/EE/85D-38) Avail: NTIS HC A17/MF A01 CSCL 01B

Proportional plus integral controllers are designed for the longitudinal mode using a multivariable control law theory developed by Professor Brian Porter of the University of Salford, England. Control laws are formulated by use of a computer-aided multivariable design program entitled MULTI. In addition MULTI performs a digital closed-loop simulation for controller performance analysis. The aircraft model is developed from linearized data. Decoupling of the longitudinal output variables is achieved and demonstrated by four maneuvers (pitch-pointing, vertical translation, direct climb, and constant g pull-up). Plant parameter variation effects are also examined. Destabilizing effects to include actuator and sensor dynamics computational time delay random Gaussian sensor noise and simulation nonlinearities are included. Results show stable responses for all simulations. Except for the most demanding simulations (all destabilizing effects considered), controller responses are smooth and well behaved. Recommendations include proposed future work in thrust vector modeling and suggested improvements to the computer-aided design program, MULTI. GRA

**N86-24707#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**AN LQG UP-AND AWAY FLIGHT CONTROL DESIGN FOR THE STOL F-15 AIRCRAFT M.S. Thesis**

R. A. HOUSTON Dec. 1985 243 p refs
(AD-A164108; AFIT/GE/ENG/85D-21) Avail: NTIS HC A11/MF A01 CSCL 01D

A robust controller for the STOL F-15 aircraft is developed using the LQG/LTR (linear system model, quadratic cost, Gaussian models of uncertainty used for controller synthesis, with loop transfer recovery techniques of tuning the filter in the loop for control robustness enhancement) methods. Full state feedback controllers are synthesized using CGT/PI (Command Generator Tracking feedforward compensator to provide direct incoporation of flying qualities into the design process, with proportional plus integral feedback control) synthesis, using implicit model following techniques to improve full state robustness characteristics. Finally, a Kalman filter is used to replace the unrealistic assumption of full state availability with estimated states, using a LTR scheme to recover as much full state robustness characteristics as possible. GRA

**N86-24708#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**LQG/LTR DESIGN OF A ROBUST FLIGHT CONTROLLER FOR THE STOL F-15 M.S. Thesis**

G. L. GROSS Dec. 1985 182 p refs
(AD-A164111; AFIT/GAE/ENG/85D-1) Avail: NTIS HC A09/MF A01 CSCL 17G

A robust controller for the approach and landing phase of the Short Take-off and Landing (STOL) F-15 is developed via LQG/LTR (Linear System model, Quadratic cost, Gaussian models of uncertainty, used for controller synthesis, with Loop Transmission Recovery techniques of tuning the filter in the loop for control robustness enhancement) methods. Reduced-order full-state feedback controllers are synthesized using CGT/PT (Command Generator Tracking feedforward compensator to incorporate handling qualities, with Proportional plus Integral feedback) synthesis, specifically using implicit model following to provide good robustness characteristics in the full-state feedback case. The robustness is fully assessed using realistic simulations of the real-world system with meaningful deviations from design conditions. Once a Kalman filter is embedded into the loop to estimate states rather than assuming artificial access to all states, LTR methodology is used to preserve as much robustness as possible. A full assessment of performance and robustness of these final implementable designs is provided. GRA

**N86-25384#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**AN LQG UP-AND AWAY FLIGHT CONTROL DESIGN FOR THE STOL F-15 AIRCRAFT M.S. Thesis**

R. A. HOUSTON Dec. 1985 243 p refs
(AD-A164108; AFIT/GE/ENG/85D-21) Avail: NTIS HC A11/MF A01 CSCL 01D

A robust controller for the STOL F-15 aircraft is developed using the LQG/LTR (linear system model, quadratic cost, gaussian models of uncertainty used for controller synthesis, with loop transfer recovery techniques of tuning the filter in the loop for control robustness enhancement) methods. Full state feedback controllers are synthesized using CGT/PI (Command Generator Tracking feedforward compensator to provide direct incoporation of flying qualities into the design process, with proportional plus integral feedback control) synthesis, using implicit model following techniques to improve full state robustness characteristics. Finally, a Kalman filter is used to replace the unrealistic assumption of full state availability with estimated states, using a LTR scheme to recover as much full state robustness characteristics as possible. GRA

**N86-25603#** Joint Publications Research Service, Arlington, Va.
**ROLE OF OPTIMIZATION METHODS IN IMPROVEMENT OF FLIGHT CONTROL FOR AIRPLANES Abstract Only**
G. M. KASHIN *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 10 7 Feb. 1986 Transl. into ENGLISH from Standarty i Kachestvo (Moscow, USSR), no. 12, Dec. 1984 p 15-18
Avail: NTIS HC A06/MF A01

While conventional computer aided automatic flight control alone improves the static and dynamic characteristics of aircraft, active automatic control can further improve the flight mechanics by means of reduction of takeoff mass. Such a control system is capable of performing other additional functions as well, namely relaxing the constraints on natural static stability, reducing the loads involved in maneuvers, increasing the stability margin under flutter, damping elastic vibrations in a turbulent atmosphere, direct control of lift and lateral forces, improving the flight aerodynamics, prevention of dives and spins, and improving passenger comfort. The stability margin is reduced by increasing the stability level. The design of such a system is based on analysis of surges and vibrations, requires inclusion of corrective filters, and calls for optimization of the control algorithm for the special application. One approach proposed is the approach taken for optimizing the parameters of standardization objects. Author

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-35155#**
**SIMULATION AND MEASUREMENT OF ENGINE INFLUENCES IN A TWO-JET AIRCRAFT MODEL USING MODEL ENGINES [SIMULATION UND MESSUNG VON TRIEBWERKSEINFLUESSEN AN EINEM ZWEISTRAHLIGEN FLUGZEUGMODELL MIT HILFE VON MODELLTRIEBWERKEN]**
D. ECKERT (Duits-Nederlandse Windtunnel Emmeloord, Netherlands) and W. BURGSMUELLER (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 16 p. In German.
(DGLR PAPER 85-092)

The calibration, simulation, a measurement technology used in the German-Dutch Wind Tunnel DNW to study engine influences in a two-jet aircraft model are described. The accuracy of the interference evaluation achieved in the DNW using pressure distribution and six-component power measurements on an Airbus model is reported. Potential improvements that could be made to improve design results antecedent to flight tests are discussed. C.D.

**A86-35166#**
**HELICOPTER TEST INSTALLATION ROTEST IN DNW - APPLICATION AND RESULTS [HUBSCHRAUBER-VERSUCHSANLAGE ROTEST IM DNW - EINSATZ UND ERGEBNISSE]**
H.-J. LANGER, G. BRAUN, and B. JUNKER (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 14 p. In German.
(DGLR PAPER 85-113)

The model standardization and functioning of the helicopter test installation RoTeSt in DNW is discussed. The choice of standardization factors for the different aspects of the installation is addressed, and a block diagram of the installation signal flow is given. Tests conducted on various rotors in the installation's wind tunnel are reviewed, showing results on the relation between model rotor operation points and flight states, on the derivative of the longitudinal angle of control as a function of velocity, on correction values for rotor angle of attack for various measuring section configurations and mast angles of inclination, and on the effect of tunnel temperature on the rotor thrust for constant rotational speed. Comparison results for various rotors are given, including accelerations, dynamic momentum behavior, and measurements of downwash. C.D.

**A86-35213**
**REQUIREMENTS FOR SECOND GENERATION AIRCRAFT WEIGHING SYSTEMS**
C. R. URSELL, II and R. L. WILBUR (Southwest Research Institute, San Antonio, TX) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 6 p.
(SAWE PAPER 1669)

Weighing of aircraft to determine weights, distribution and center of gravity is becoming more and more a critical and necessary operation. In order to achieve the desired goals, ten basic requirements have been set forth for the second generation of new weighting systems. These requirements involve accuracy, repeatability, linearity, simplicity, portability, ruggedness, size/weight, maintainability, calibration and temperature correction. These have been achieved in two prototype systems that have been in operation for the past five years. Author

**A86-36941**
**ENGINEERING FLIGHT SIMULATION - A REVOLUTION OF CHANGE**
T. L. FRASER and C. E. PHILLIPS (Boeing Computer Services Flight Systems Laboratory, Seattle, WA) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 11-17.
(SAE PAPER 851901)

Issues which require consideration when developing an engineering simulation facility are presented, with emphasis placed on the incorporation of a dynamic computing technology into short and long-term planning. The effects of the operation environment, simulation growth, and simulation payoff are discussed in relation to external influences of computer architecture, re-education of the programmer, and simulation user help. It is concluded that new simulation technology may include the application of a modular computing architecture in the form of multi-processors and engineering workstations, as well as extensive input/output and file networking systems. Moreover, it would include the selection and education of new programming languages and the development of adequate help systems. K.K.

**A86-36944**
**CAPABILITIES OF AIRBORNE AND GROUND BASED FLIGHT SIMULATION**
S. R. MARKMAN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 35-42.
(SAE PAPER 851944)

Major capabilities and limitations of ground based and in-flight simulation are discussed, and the unique role of in-flight simulation for test pilot training is demonstrated. Inherent advantages of ground-based simulation include unlimited flexibility, easy design modification, the absence of flight safety issues and the early evaluation of new systems and aerodynamic effects. However, motion and visual cues are insufficiently simulated but they are readily available in in-flight simulation, together with greater control precision. Disadvantages associated with this mechanism include a lack of control power, less flexibility in reconfiguring cock-pit equipment, and a psychological barrier connected to safety-pilot presence. It is concluded that the use of both types of simulators in a combined flight simulation program is justified and desirable. K.K.

**A86-37087*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CURRENT WIND TUNNEL CAPABILITY AND PLANNED IMPROVEMENTS AT THE NASA LANGLEY RESEARCH CENTER**

R. E. BOWER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Testing Conference, 14th, West Palm Beach, FL, Mar. 5-7, 1986. 65 p. refs
(AIAA PAPER 86-0727)

NASA Langley's major wing wind tunnels and the projected facilities planned to be completed by 1988 are presented. Special capabilities, uses, and the improvements done during the Langley's tunnel revitalization program are described for the following facilities: (1) the 30 x 60-ft subsonic tunnel, (2) the 4 x 7-m low-speed testing tunnel, (3) the Low-Turbulence Tunnel, (4) the Spin Tunnel, (5) the National Transonic Pressure Tunnel, (6) Transonic Cryogenic Tunnel, (7) the National Transonic Facility, (8) the 16-ft Transonic Tunnel, (9) the Transonic Dynamic Tunnel, (10) the Unitary Plan Wind Tunnel, and (11) a new 20-inch supersonic wind tunnel which is currently undergoing final checkout. The design concept of an extremely-low disturbance level supersonic tunnel, the upgrading plans for the hypersonic aerothermal complex, and the present and planned capabilities for testing the hydrogen-fueled Scramjet engines are also presented. In addition, uses of inexpensive simple-to-operate research wind tunnels are discussed. Tunnel diagrams and graphs of upgrade results are included. I.S.

**A86-37090#**

**THE DEVELOPMENT AND CALIBRATION OF AN ACOUSTIC WALL TRANSONIC TEST SECTION**

R. L. BENGELINK, R. P. DOERZBACHER, and A. J. KRYNYTZKY (Boeing Commercial Airplane Co., Seattle, WA) AIAA, Aerodynamic Testing Conference, 14th, West Palm Beach, FL, Mar. 5-7, 1986. 10 p. refs
(AIAA PAPER 86-0759)

The Boeing transonic wind tunnel has been equipped with an optional test section to allow near-field acoustic measurements for many types of models, including propfan-type propulsion simulators. Acoustic requirements led to a design using unventilated walls made of small cell, acoustic foam 12-in thick covered with a thin 50 percent porosity, perforated plate. In order to ensure maximum effectiveness of the sound material forward of the model noise-generating parts, a circumferential slot to reduce wall boundary layer momentum thickness is included in the configuration. Much of the test section development was accomplished using the 1/20-scale pilot transonic wind tunnel. Operational limits due to model blockage, wall divergence sensitivity, wall loads, and wall boundary layer slot performance were evaluated in the pilot facility. Also included in the development was a computational fluid dynamics Euler code analysis of a model with actuator disc for evaluation of wall interference due to propfan thrust. The code also addressed flow qualities around a propfan with wall boundary layer bleed. Author

**N86-24710*#** National Aeronautics and Space Administration, Washington, D.C.

**WIND TUNNEL TECHNOLOGY FOR THE DEVELOPMENT OF FUTURE COMMERCIAL AIRCRAFT**

J. SZODRUCH Mar. 1986 45 p refs Transl. into ENGLISH Conference Paper "Windkanaltechnologie fur die Entwicklung Zukunftiger Verkehrsflugzeuge" Hamburg, West Germany, DGLR Paper 84-127 Presented at the German Aerospace Society Annual Convention, Hamburg, West Germany, 1-3 Oct. 1984 Original language doc. was announced in IAA as A85-40340 Transl. by SCITRAN, Inc., Santa Barbara, Calif. Original doc. prep. by Deutsche Gesellschaft fur Luft- und Raumhafrt
(Contract NASW-4004)
(NASA-TM-88390; NAS 1.15:88390; DGLR-PAPER-84-127)
Avail: NTIS HC A03/MF A01 CSCL 14B

Requirements for new technologies in the area of civil aircraft design are mainly related to the high cost involved in the purchase of modern, fuel saving aircraft. A second important factor is the long term rise in the price of fuel. The demonstration of the benefits of new technologies, as far as these are related to aerodynamics, will,for the foreseeable future, still be based on wind tunnel measurements. Theoretical computation methods are very successfully used in design work, wing optimization, and an estimation of the Reynolds number effect. However, wind tunnel tests are still needed to verify the feasibility of the considered concepts. Along with other costs, the cost for the wind tunnel tests needed for the development of an aircraft is steadily increasing. The present investigation is concerned with the effect of numerical aerodynamics and civil aircraft technology on the development of wind tunnels. Attention is given to the requirements for the wind tunnel, investigative methods, measurement technology, models, and the relation between wind tunnel experiments and theoretical methods. F.M.R.

**N86-25385#** Drexel Univ., Philadelphia, Pa. Dept. of Civil Engineering.

**MATERIALS FOR EMERGENCY REPAIR OF RUNWAYS Final Report, 1 Apr. 1984 - 14 Feb. 1985**

S. POPOVICS 20 Mar. 1985 236 p refs
(Contract AF-AFOSR-0245-83)
(AD-A164225; REPT-001120-1; AFOSR-85-1229TR) Avail: NTIS HC A11/MF A01 CSCL 11B

The primary objective of this project was to identify or develop an inorganic cementing material that is suitable for emergency repair of damaged airport runways under war conditions. In the first half of the work several commercially available rapid hardening cements were screen-tested as presented in an earlier progress report. It was established on this basis that the SET-45 formulas and their modifications appeared to be the most promising for achieving the given objectives of this project. These objectives were: at least 2000 psi compressive strength at the age of 1 hour; adequately long setting time; good bond to old concrete; and minimum shrinkage under every weather condition. Since then both mechanical (compressive and flexural strengths, bond, shrinkage, etc.) and physicochemical tests (X-ray diffraction, scanning electron microscopy, infrared spectroscopy, etc.) were performed with these materials to see the technically important properties of these cements under various curing conditions and learn about the basic nature of these materials. GRA

## 10

## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-34112#**

**COMMERCIAL APPLICATIONS OF THE NAVSTAR GLOBAL POSITIONING SYSTEM**

M. W. MILLER (Rockwell International Corp., Satellite Systems Div., Washington, DC) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 10 p.

The characteristics and operation of the Global Positioning System (GPS) are described. The benefits GPS will provide to civilian air, sea, land, and space travel are discussed. Specific commercial applications for the satellite system, which include air traffic control, time synchronization, and oil exploration, are analyzed. I.F.

**A86-34195**
**CAN WE DEVELOP THE 1.5 MILLION POUND AEROSPACE PLANE?**
D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 26-30.

A technology readiness and economic feasibility evaluation is made of hypersonic, 'transatmospheric' aerospace vehicles; attention is given to the prospects for propulsion systems capable of attaining the Mach 25 escape velocity needed to reach low earth orbits and duplicating many of the functions currently undertaken by the Space Shuttle. Either two integrated propulsion systems or two 'staged' vehicles may be employed to yield the requisite operational capabilities. The claims of competing airbreathing and nonairbreathing (rocket) propulsion systems are evaluated. O.C.

**A86-35217** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**WEIGHTS ASSESSMENT FOR ORBIT-ON-DEMAND VEHICLES**
I. O. MACCONOCHIE, J. A. MARTIN (NASA, Langley Research Center, Hampton, VA), C. A. BREINER, and J. A. CERRO (Kentron International, Inc., Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 32 p. refs
(SAWE PAPER 1674)

Future manned, reusable earth-to-orbit vehicles may be required to reach orbit within hours or even minutes of a mission decision. A study has been conducted to consider vehicles with such a capability. In the initial phase of the study, 11 vehicles were sized for deployment of 5000 lbs to a polar orbit. From this matrix, two of the most promising concepts were resized for a modified mission and payload. A key feature of the study was the use of consistent mass estimating techniques for a broad range of concepts, allowing direct comparisons of sizes and weights. Author

**N86-24722*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**PASSIVE EDDY-CURRENT DAMPING AS A MEANS OF VIBRATION CONTROL IN CRYOGENIC TURBOMACHINERY**
R. E. CUNNINGHAM Feb. 1986 14 p refs
(NASA-TP-2562; E-2762; NAS 1.60:2562) Avail: NTIS HC A02/MF A01 CSCL 13I

Lateral shaft vibrations produced by a rotating unbalance weight were damped by means of eddy currents generated in copper conductors that were precessing cyclicly in the gap formed by the pole faces of C-shaped, permanent magnets. The damper assembly, which was located at the lower bearing support of a vertically oriented rotor was completely immersed in liquid nitrogen during the test run. The test rotor was operated over a speed range from 800 to 10,000 rpm. Three magnet/conductor designs were evaluated. Experimental damping coefficients varied from 180 to 530 N sec/m. Reasonable agreement was noted for theoretical values of damping for these same assemblies. Values of damping coefficients varied from 150 to 780 N sec/m. The results demonstrate that passive eddy-current damping is a viable candidate for vibration control in cryogenic turbomachinery. Author

## 11

## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-34650*** Vrije Universiteit, Brussels (Belgium).
**AN INTERNAL VARIABLE ASSISTED FORMULATION OF MOISTURE SORPTION MODELS FOR POLYMERS AND COMPOSITES**
C. C. HIEL (Brussel, Vrije Universiteit, Brussels, Belgium) and M. J. ADAMSON (NASA, Ames Research Center, Moffett Field, CA) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 813-818. refs

The purpose of the paper is to demonstrate that constitutive equations for moisture sorption and swelling can be obtained with an internal variable method which is rooted in the theory of irreversible thermodynamics. Realism is injected into the model through the concept of free volume. The power of the method is illustrated by the solution of the formidable nonlinear boundary value problem for diffusion with swelling-stress dependent diffusivity. Author

**A86-35179#**
**COMPARISON OF AL ALLOYS AND CARBON FIBER COMPOSITE MATERIALS IN AIRCRAFT CONSTRUCTION [VERGLEICH VON AL-LEGIERUNGEN UND CFK-WERKSTOFFEN IM FLUGZEUGBAU]**
F. J. ARENDTS (Stuttgart, Universitaet, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 43 p. In German. refs
(DGLR PAPER 85-136)

A comparison is made between Al alloys and carbon fiber composite (CFC) materials in static loading, emphasizing the adaptability of the results to a variety of situations. Results are presented for tension, pressure, Euler bending, buckling, shear, and torsion. The notch impact strength of CFC is taken into consideration. The fatigue behavior of both materials is compared. The damage in metal sheets under tension is compared with a crack in aluminum-lithium and a pressure-loaded laminate is compared with delamination in CFC. Results of an extended study on weight-optimal materials for a spherical pressure cup in a commercial aircraft are presented. The inherent tendency of orthotropic materials to form elastomechanical couplings vic the elasticity law is discussed. C.D.

**A86-35180#**
**ARALL (ARAMID REINFORCED ALUMINIUM LAMINATES), - A HYBRID COMPOSITE WITH A GREAT RESISTANCE AGAINST FATIGUE CRACK PROPAGATION**
R. MARISSEN (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 28 p. DFG-supported research. refs
(DGLR PAPER 85-137)

Modern aircraft structures are subjected to high-level fatigue stresses, and suitable structural materials with a high resistance to such stresses are needed. The present paper is concerned with such a material, taking into account the hybrid composite Arall (Aramid Reinforced Aluminum Laminates). Advantages of Arall are related to extremely low crack growth rates, even at high stress levels, and a large critical crack length. The material consists of thin aluminum alloy sheets (0.3 to 0.5 mm) and layers in which Aramid fibers are incorporated in a structural adhesive. Attention is given to a description of Arall, the statical properties of Arall, the technological properties of Arall, its potential applications, and the observed fatigue mechanisms. G.R.

**A86-35226**

**STRAINING FOR WEIGHT SAVINGS IN ADVANCED COMPOSITES**

L. J. LINNER (Lockheed-California Co., Burbank, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 70 p. refs

(SAWE PAPER 1685)

The use of advanced composites in aircraft structures is discussed with emphasis on the possibility of increasing the potential levels of strain allowables for the composites. In particular, attention is given to the principal design criteria, test results for new toughened resin systems, an analysis of the primary failure modes, and estimation of weight savings resulting from the use of advanced composites. The study provides a realistic approach to the use of advanced composites in structural design by taking advantage of the high strain allowables while addressing nonoptimum constraints. V.L.

**A86-35640*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECT OF FIBER AND MATRIX MAXIMUM STRAIN ON THE ENERGY ABSORPTION OF COMPOSITE MATERIALS**

G. L. FARLEY (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 583-588. refs

Static crushing tests were conducted on graphite composite tubes to examine the influence of fiber and matrix maximum strain at failure on the energy absorption capability of graphite reinforced composite material. Fiber and matrix maximum strain at failure were determined to significantly effect energy absorption. The higher strain at failure composite material system, AS-4/5245, exhibited superior energy absorption capability compared to AS-4/934, T300/5245 or T300/934 composite material. Results of this investigation suggest that to achieve maximum energy absorption from a composite material a matrix material that has a higher strain at failure than the fiber reinforcement should be used. Author

**A86-35641**

**PROCESS DEVELOPMENT AND TEST EVALUATION OF CAST, HIP AND HEAT TREATED TITANIUM UH-60A M.R. DAMPER BRACKET**

J. KOPCHIK, M. M. SCHWARTZ, and S. SILVERSTEIN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 589-593. Army-supported research.

Sikorsky Aircraft recently completed this U.S. Army funded program which produced and qualified a cast titanium Main Rotor Damper Bracket for the UH-60A helicopter to replace the existing forged and machined titanium bracket at a lower cost. The Ti-6Al-4V investment casting was HIP, heat treated, machined and full scale fatigue tested as a part of the acceptance of the material properties and processing techniques needed for production implementation. A series of tensile and fatigue tests also were performed (as well as non-destructive, dimensional, and chemical evaluation of the cast parts). The material for these small scale and the full scale tests came from the successful preproduction of forty-four (44) full scale damper bracket investment castings. Author

**A86-36178**

**COMPARISON OF THE STRENGTH AND DAMAGE TOLERANCE OF ALUMINIUM ALLOYS**

L. SCHWARMANN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) International Journal of Fatigue (ISSN 0142-1123), vol. 8, April 1986, p. 73-77. refs

The static strengths, crack growth lives and residual strengths have been predicted for a variety of aluminum alloys used in aeronautical structures, and the influence of product form and heat treatment on these properties assessed. Recommendations are made concerning the best plate or sheet material to use when high strength or good fatigue performance is required. Author

**A86-36335**

**STRUCTURAL MATERIALS IN AERONAUTICS - PROSPECTS AND PERSPECTIVES**

G. G. POPE (Royal Aircraft Establishment, Farnborough, England) Aerospace (UK) (ISSN 0305-0831), vol. 13, April 1986, p. 16-22.

The factors influencing choices of materials for aircraft components are reviewed, along with recent advances in available materials and their applications. The primary concern is weight minimization, followed by maximized strength and stiffness, acceptable life cycle costs and fatigue resistance. The operational environment is of concern, especially near oceans due to corrosion for metals (which can be coated) and weakening of composites (due to water absorption). New aircraft propulsion system designs continually require higher operating temperatures with the concomitant desire for long-life materials. The features, performance and present and projected applications of various composites, Ti alloys, steels and Al alloys, particularly for military purposes, are examined. M.S.K.

**A86-36750**

**WHAT IS THE CHOICE FOR PRIMARY AIRCRAFT STRUCTURES - COMPOSITE OR ALUMINUM MATERIALS? [QUE FAUT-IL CHOISIR POUR LES OEUVRES VIVES - LES MATERIAUX COMPOSITES OU L'ALUMINIUM?]**

B. LIARD (Brochier, S.A., Nevilly-sur-Seine, France) Materiaux et Techniques (ISSN 0032-6895), vol. 74, Jan.-Feb. 1986, p. 37-39. In French.

Aluminum alloys have been the material of choice for aircraft structures for decades due to their light weight, strength and fatigue resistance. Composite materials, at first comprising glass fiber-reinforced polymers, have been used for radomes and secondary structures. The high strength, low weight and fatigue resistance of carbon fiber reinforced plastics (CFRP) have led to their consideration as replacements for aluminum. CFRP materials are at least as fatigue resistant and as stiff as steel and offer significant overall gains in weight reduction if used as aircraft primary structures relative to the same structures made from aluminum. CFRP helicopter blades have already lasted up to four times as long as metal blades, but must be proven to structually resist the separation, shocks and shear forces experienced by metallic aircraft components before being employed in wings and fuselages. The new PEEK-based CRFPs have satisfactory shock resistance, although no field-ready techniques have yet been developed for repairs. The large potential market for CFRPs of sufficient material properties is delineated, along with the properties of the competing Al-Li alloys for the next generations of aircraft. M.S.K.

**A86-36874#**

**A TRANSPORT MODEL FOR FLAMMABILITY OF PREMIXED GASES**

A. J. SABER (Concordia University, Montreal, Canada) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 177-181. refs

(Contract NSERC-A-4209)

Criteria for the prediction of flammability limits of premixed gases are presented. The model used incorporates gas phase diffusion in the case of a relatively low pressure, stationary, one-dimensional flow. No additional physio-chemical properties are assumed. Applications include the selection of minimum air/fuel ratios for synthetic aircraft fuels. The model can be extended by relaxing the assumptions and the approach leads directly to numerical solution. Author

**A86-37068*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### DROP TESTING AND ANALYSIS OF SIX-FOOT DIAMETER GRAPHITE-EPOXY FRAMES

R. L. BOITNOTT (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) and H. D. CARDEN (NASA, Langley Research Center, Hampton, VA) AHS, National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, Apr. 7-9, 1986, Paper. 10 p. refs

Graphite-epoxy frames were drop tested onto a concrete floor to simulate crash loadings. The frames have Z-shaped cross-sections typical of designs often proposed for fuselage structure of advanced composite transports. The 6-foot diameter of the frames was chosen to reduce specimen fabrication costs and to facilitate testing. Response of the frames from accelerometer, strain gage, and photographic measurements are presented which characterize the behavior under 25-30 fps vertical impact velocity onto concrete. Failure of the graphite-epoxy frames involved a complete separation through the cross section near the impact point. All damage to the composite frame was confined to an area close to the impact point. Failure of aluminum frames tested for comparison were different from the composite specimens. The aluminum frames yielded (plastic hinges formed) at several locations around the lower portion of the frame without failing completely across the section. Author

**A86-37073*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### NA2SO4 INDUCED CORROSION OF NICKEL AT HIGH TEMPERATURE

A. K. MISRA (NASA, Lewis Research Center, Cleveland, OH) ASM, International Conference on Surface Modifications and Coatings, Toronto, Canada, Oct. 14-16, 1985, Paper. 18 p. refs

Sodium sulfate-induced corrosion of nickel was studied at 900 C as a function of oxygen partial pressure. For high O2 partial pressures, accelerated corrosion during the first few minutes occurred by rapid penetration of the melt along the metal grain boundaries. A mechanism is proposed to explain this phenomenon. Repetitive scale metal detachment was observed for corrosion in lower O2 partial pressures and during the later period of corrosion in higher O2 partial pressures. The effect of preoxidation on the hot corrosion has also been studied. An induction period is observed before the onset of rapid corrosion for the preoxidized samples; the onset of rapid corrosion is associated with sudden cracking of the scale. The length of the induction period for the preoxidized samples is a function of the length of preoxidation, and appears to be related to the structure of the oxide scale after the preoxidation treatment. Author

**A86-37118**

### COMPRESSIVE STRENGTH OF IMPACT DAMAGED GRAPHITE EPOXY LAMINATES

R. JONES and A. A. BAKER (Ministry of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 402-414. refs

A major long-term objective in the evolution of advanced fiber composites as aircraft structural materials must be the establishment of a damage tolerance methodology. The availability of this methodology would greatly aid the design of safe, efficient composite structures as well as their management in service. There are, however, many difficulties in meeting this objective, including the multiplicity of failure modes in the composites, the numerous types of potentially significant defects which may arise during manufacture or in service, and sensitivity to moisture and temperature. Author

**A86-37134**

### METHOD TO DETERMINE THE COMPLETE THREE-DIMENSIONAL ELASTIC COMPLIANCE MATRIX OF COMPOSITE MATERIALS

A. RUEBBEN and G. SCHARR (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 760-773. refs

The use of composite materials has rapidly progressed in the past years. Especially in aircraft and aerospace structures, the percentage of components made from composite materials constantly increases, yet the knowledge of many fundamental material properties is still insufficient. The correct calculation of the stress-strain behavior of space structures requires the exact determination of the complete compliance matrix, i.e. of the three-dimensional coefficients of elasticity. The present paper describes an extended testing and computing method to determine all three-dimensional elastic coefficients of composite materials dependent on temperature. The experiments are isothermal, static, short-term tensile tests and short-term torsion tests with low loading to secure elastic behavior. The torsion testing machine was developed according to Krabbe (1960) and Neuhaus (1981). The applied computing method derives from studies by Hoerig (1957). Author

**A86-37136**

### ADVANCED COMPOSITES - THE STRUCTURAL REVOLUTION

R. C. FORNEY (Du Pont de Nemours and Co., Wilmington, DE) Journal of Metals (ISSN 0148-6608), vol. 38, March 1986, p. 18-20.

An evaluation is made of the development status and development prospects of advanced composites, with attention to projected gains obtained by means of them in design practices, manufacturing methods, energy conservation, and product utility and diversity. Major performance improvements attributable to advanced composites are noted in the aerospace industry, where they have made possible such innovative aircraft configurations as the X-29 forward-swept wing aircraft, and in the automotive industry, where significant parts count reductions are expected from composites-based construction methods. Composites are also noted to lend themselves to automated production methods. Attention is given to the long term socioeconomic consequences of composite materials' increasing use. O.C.

**A86-37137**

### ARAMID FIBER COMPOSITES FOR GENERAL ENGINEERING

D. TANNER, A. K. DHINGRA, and J. J. PIGLIACAMPI (Du Pont de Nemours and Co., Textile Fibers Dept., Wilmington, DE) Journal of Metals (ISSN 0148-6608), vol. 38, March 1986, p. 21-25. refs

The para-aramid known commercially as poly p-phenyleneterephthalamide (PPD-T) consists of liquid crystalline domains oriented in the direction of applied shear during fiber extrusion operations. This high degree of orientation accounts for PPD-T's exceptional fiber strength and stiffness. It is projected that aircraft applications of PPD-T will emphasize damage tolerance and crashworthiness for primary structures. Attention is given to ongoing development efforts to improve matrix interface bonding in composites, including those with novel thermoplastic resin matrices, as well as antiballistic armor, asbestos-replacing composites, and rubber-matrix composites. O.C.

**N86-24760*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

### EVALUATION OF CAPILLARY REINFORCED COMPOSITES Contractor Report, Sep. 1984 - Sep. 1985

J. E. CAHILL, J. F. HALASE, W. K. SOUTH, and L. J. STOFFER Sep. 1985 141 p Original contains color illustrations
(Contract NAS3-24386)
(NASA-CR-175061; NAS 1.26:175061) Avail: NTIS HC A07/MF A01 CSCL 11D

Anti-icing of the inlet of jet engines is generally performed with high pressure heated air that is directed forward from the

compressor through a series of pipes to various manifolds located near the structures to be anti-iced. From these manifolds, the air is directed to all flowpath surfaces that may be susceptible to ice formation. There the anti-icing function may be performed by either heat conduction or film heating. Unfortunately, the prospect of utilizing lighweight, high strength composites for inlet structures of jet engines has been frustrated by the low transverse thermal conductivity of such materials. It was the objective of this program to develop an advanced materials and design concept for anti-icing composite structures. The concept that was evaluated used capillary glass tubes embedded on the surface of a composite structure with heated air ducted through the tubes. An analytical computer program was developed to predict the anti-icing performance of such tubes and a test program was conducted to demonstrate actual performance of this system. Test data and analytical code results were in excellent agreement. Both indicate feasibility of using capillary tubes for surface heating as a means for composite engine structures to combat ice accumulation.
Author

**N86-24781#** Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
**ALTITUDE IGNITION/LEAN DECEL STUDY Final Report, Aug. 1983 - Jan. 1985**
D. ANDREADIS Nov. 1985 88 p
(Contract F33615-83-C-2329)
(AD-A163052; P/W/GPD-FR-18710; AFWAL-TR-85-2054) Avail: NTIS HC A05/MF A01 CSCL 21B

Analytical tasks consisting of new or improved models for predicting altitude ignition and lean deceleration blowout are developed. The approach taken was to describe the ignition and flame stabilization limits in terms of characteristic time models. Characterisitic times associated with chemical kinetics, fuel evaporation and hot flow residence are quantified for ignition and lean deceleration blowout limits. These expressions were interrelated according to the criteria for successful ignition and flame stabilization. Statistical analysis was used to compare the various expressions and select the appropriate terms that formulate models which best fit the data for altitude ignition and lean deceleration blowout. The models linearly correlate variations in combustor pressure, inlet temperature, fuel-air ratio, fuel temperature, air velocity, pressure drop, combustor front end geometry and injector size using existing data from USAF, Navy, NASA and P&W sponsored programs on operability performance of military and commercial gas turbine combustors. These models have been based entirely on full scale engine test. GRA

**N86-24788#** National Bureau of Standards, Gaithersburg, Md. Center for Fire Research.
**DATA SOURCES FOR PARAMETERS USED IN PREDICTIVE MODELING OF FIRE GROWTH AND SMOKE SPREAD**
D. GROSS Sep. 1985 41 p
(PB86-130986; NBSIR-85/3223) Avail: NTIS HC A03/MF A01 CSCL 13L

Sources of data needed for predictive modeling of fire growth by FAST and ASET, two computer codes developed at the Center for Fire Research, are identified for a few selected materials. Data includes thermophysical properties of compartment lining materials and burning rates and combustion product generation rates for typical combustible contents. GRA

**N86-24818*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Materials Science and Engineering.
**THERMAL-MECHANICAL FATIGUE BEHAVIOR OF NICKEL-BASE SUPERALLOYS Final Report**
R. M. PELLOUX and N. MARCHAND Mar. 1986 186 p refs
(Contract NAG3-280)
(NASA-CR-175048; NAS 1.26:175048; USAAVSCOM-TR-86-C-4)
Avail: NTIS HC A09/MF A01 CSCL 11F

The main achievements of a 36-month research program are presented. The main objective was to gain more insight into the problem of crack growth under thermal mechanical fatigue (TMF) conditions. This program was conducted at M.I.T. for the period of September 1982 to September 1985. The program was arranged into five technical tasks. Under Task I, the literature of TMF data was reviewed. The goal was to identify the crack propagation conditions in aircraft engines (hot section) and to assess the validity of conventional fracture mechanics parameters to address TMF crack growth. The second task defined the test facilities, test specimen and the testing conditions needed to establish the effectiveness of data correlation parameters identified in Task I. Three materials (Inconel X-750, Hastelloy-X, and B-1900) were chosen for the program. Task II was accomplished in collaboration with Pratt & Whitney Aircraft engineers. Under Task III, a computerized testing system to measure the TMF behavior (LCF and CG behaviors) of various alloys systems was built. The software used to run isothermal and TMF tests was also developed. Built around a conventional servohydraulic machine, the system is capable of push-pull tests under stress or strain and temperature controlled conditions in the temperature range of 25C to 1050C. A crack propagation test program was defined and conducted under Task IV. The test variables included strain range, strain rate (frequency) and temperature. Task V correlated and generalized the Task IV data for isothermal and variable temperature conditions so that several crack propagation parameters could be compared and evaluated. The structural damage (mode of cracking and dislocation substructure) under TMF cycling was identified and contrasted with the isothermal damage to achieve a sound fundamental mechanistic understanding of TMF. Author

**N86-24821#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**CONSTANT-LOAD-AMPLITUDE FATIGUE CRACK GROWTH TESTING OF CAST ALUMINUM ALLOYS A201-T7 AND A357-T6 Final Report, Mar. 1983 - Apr. 1984**
J. D. TIRPAK Nov. 1985 60 p refs
(AD-A163494; AFWAL-TR-85-4096) Avail: NTIS HC A04/MF A01 CSCL 11F

This report is a repository of constant-load-amplitude fatigue crack growth rate data for cast aluminum alloys A201-T7 and A357-T6. Conditions were R=0.1, room temperature, lab air, and growth rates were above .0000001 m/cycle. The data herein was published for use by the aerospace community. From this data, it appears as if cast aluminum alloys possess some variability with respect to fatigue crack growth rate. For the most part though, the data is to serve as a nucleus for evaluating fatigue and fracture data for aluminum casting alloys, and generating impetus for further evaluation of these alloys with respect to fracture. GRA

**N86-25370#** Cambridge Univ. (England). Dept. of Metallurgy and Materials Science.
**ASPECTS OF SMALL CRACK GROWTH**
M. N. JAMES and J. F. KNOTT *In* AGARD Damage Tolerance Concepts for Critical Engine Components 16 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

The nature of small defects which occur in engineering components and structures, and their subsequent growth to a size detectable by nondestructive inspection techniques are discussed. Consideration is given to fundamental aspects such as the modifying influence of residual stresses and crack closure on the growth of small cracks. Possible differences between laboratory test data and in-service crack growth are highlighted. Practical aspects are illustrated with specific reference to the example of the safety-critical high pressure turbine disc of an aeroengine.
Author

**N86-25376#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Materials Lab.
**ADVANCED QUANTITATIVE METHODS FOR NONDESTRUCTIVE EVALUATION**
D. E. CHIMENTI and T. J. MORAN *In* AGARD Damage Tolerance Concepts for Critical Engine Components 17 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Over the past decade and a half progress in nondestructive evaluation (NDE) methods which yield quantitative flaw information has been considerable and has sparked a revolution in the way industry and government view the capabilities and benefits of quality assurance or component integrity. Almost no NDE technique, new or established, is selected for research and development without examining its potential for providing accurate, quantitative defect information. Concurrent with this trend has been the increasing use of fracture mechanics in the design and life management of aircraft systems, placing in turn stringent requirements on quantitative nondestructive evaluation (QNDE). Nowhere are these demands heavier than in the case of advanced aircraft engine alloys where critical flaw sizes are measured in hundredths of an inch. Research in NDE, therefore, has concentrated on improving defect sensitivity and reliability and providing the quantitative information essential to the new system maintenance philosphies, such as Retirement-for-Cause. In addition to the well known quantitative capabilities of standard techniques like radiography, dye penetrant, and in some cases, eddy current, developments in quantitative ultrasonics, eddy current, thermal wave techniques and exploitation of new medicial X-ray imaging methods offer alternatives with enhanced capabilities and possibly reduced cost. The state of the art in QNDE is discussed, as well as advanced methods currently in development. Author

**N86-25502*#** Rensselaer Polytechnic Inst., Troy, N.Y. Dept. of Mechanical Engineering.
**EMISSION FTIR ANALYSES OF THIN MICROSCOPIC PATCHES OF JET FUEL RESIDUES DEPOSITED ON HEATED METAL SURFACES Final Report**
J. L. LAUER and P. VOGEL 30 May 1986 95 p refs
(Contract NAG3-205)
(NASA-CR-176786; NAS 1.26:176786) Avail: NTIS HC A05/MF A01 CSCL 21D

The relationship of fuel stability to fuel composition and the development of mechanisms for deposit formation were investigated. Fuel deposits reduce heat transfer efficiency and increase resistance to fuel flow and are highly detrimental to aircraft performance. Infrared emission Fourier transform spectroscopy was chosen as the primary method of analysis because it was sensitive enough to be used in-situ on tiny patches of monolayers or of only a few molecular layers of deposits which generally proved completely insoluble in any nondestructive solvents. Deposits of four base fuels were compared; dodecane, a dodecane/tetralin blend, commercial Jet A fuel, and a broadened-properties jet fuel particularly rich in polynuclear aromatics. Every fuel in turn was provided with and without small additions of such additives as thiophene, furan, pyrrole, and copper and iron naphthenates. B.G.

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# ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-33943**
**SHARP (STATIONARY HIGH ALTITUDE RELAY PLATFORMS) TELECOMMUNICATIONS MISSIONS AND SYSTEMS**
G. W. JULL, A. LILLEMARK, and R. M. TURNER (Canadian Department of Communications, Communications Research Centre, Ottawa, Canada) IN: GLOBECOM '85 - Global Telecommunications Conference, New Orleans, LA, December 2-5, 1985, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 955-959. refs

The SHARP (Stationary High Altitude Relay Platform) system concept envisages use of microwave-powered airplanes, circling at an altitude of 21 km, as platforms to distribute telecommunications services within regions of up to about 600 km diameter. Various configurations of airplanes and power transmission systems have been examined. Studies have shown that SHARP would have the technical capability to distribute UHF mobile radio and radio telephone services along with SHF direct broadcast TV channels to rural regions. Unique features of SHARP were found to include capabilities to provide reliable radio telephone service to low power user sets and to permit frequency reuse to meet expanding traffic capacity requirements. Author

**A86-33944**
**SHARP (STATIONARY HIGH ALTITUDE RELAY PLATFORM) - RECTENNA AND LOW ALTITUDE TESTS**
J. J. SCHLESAK, A. ALDEN, and T. OHNO (Canadian Department of Communications, Communications Research Centre, Ottawa, Canada) IN: GLOBECOM '85 - Global Telecommunications Conference, New Orleans, LA, December 2-5, 1985, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 960-964. refs

This paper describes a planned low-altitude microwave-powered flight test to demonstrate several key features of the SHARP (Stationary High Altitude Relay Platform) concept. A small-scale airplane will be flown at an altitude of about 50 m, powered by microwave energy transmitted from the ground. RF power at a frequency of 2.45 GHz will be converted to dc by an array of rectennas mounted on the lower surfaces of the airplane's wings. A novel dual-polarized rectenna system has been developed for powering the scaled model. The RF to dc power conversion efficiency of this rectenna is about 60 percent. Author

**A86-34407**
**INTERNATIONAL SYMPOSIUM ON LASER ANEMOMETRY, 2ND, MIAMI BEACH, FL, NOVEMBER 17-22, 1985, PROCEEDINGS**
A. DYBBS, ED. (Case Western Reserve University, Cleveland, OH) and P. A. PFUND, ED. (Babcock and Wilcox Co., New York) Symposium sponsored by ASME. New York, American Society of Mechanical Engineers (Fluids Engineering Symposia Series. Volume FED-33), 1985, 311 p. For individual items see A86-34408 to A86-34441.

Recent developments in laser anemometry are discussed under the following headings: industrially relevant flows, optical techniques and new instrumentation, turbulent flows and boundary layers, signal processing techniques, and external and internal flows. Papers are presented on intrablade velocity mapping in transonic fan passages of gas turbine, velocity measurements within boundary layer roughness using index matching, laser-based method for analyzing speed and vorticity, and a technique to measure the size of particles in laser Doppler velocimetry applications. Other topics discussed include experiments in polydisperse two-phase turbulent flows, filter induced errors in laser anemometry using counter-processor, and physical properties of separated flows behind two-dimensional bluff bodies in uniform flows. V.L.

**A86-34410#**

### LASER ANEMOMETER MEASUREMENTS OF THE FLOW FROM A SIMULATED FUEL NOZZLE

D. R. ZIMMERMAN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN:. International Symposium on Laser Anemometry, 2nd, Miami Beach, FL, November 17-22, 1985, Proceedings . New York, American Society of Mechanical Engineers, 1985, p. 13-18. Research supported by General Motors Corp.

(Contract N00140-83-C-8894)

Two-color, two-dimensional, laser anemometer measurements were made of the axis-symmetric, swirling flow from a gas-turbine-engine, fuel-nozzle model. The flow field is characterized by two concentric, swirling, annular jets with an enclosed centerbody. The three mean velocity components, three normal stresses and two shear stresses were measured as a function of radial and axial location and Reynolds number for five geometrical configurations. The two most distinctly different geometries, co-rotating and counter-rotating annular jets, are discussed. Author

**A86-34442**

### ADVANCED TOPICS IN BOUNDARY ELEMENT ANALYSIS; PROCEEDINGS OF THE WINTER ANNUAL MEETING, MIAMI BEACH, FL, NOVEMBER 17-22, 1985

T. A. CRUSE, ED. (Southwest Research Institute, San Antonio, TX), A. B. PIFKO, ED., and H. ARMEN, ED. (Grumman Aerospace Corp., Bethpage, NY) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers , 1985, 296 p. For individual items see A86-34443 to A86-34454.

The papers presented in this volume provide an overview of current developments in boundary element methodology. Topics discussed include stress analysis of gas turbine engine structures using the boundary element method, advanced three-dimensional dynamic analysis by boundary element methods, a recursive integration technique for boundary element methods in elastostaatics, and boundary element treatment of three-dimensional elastic fracture mechanics problems. Papers are also presented on error control in three-dimensional crack modeling using the boundary element method, adaptive mesh refinement techniques for boundary element methods, and parallel processing and the solution of boundary element equations. V.L.

**A86-34444*#** United Technologies Corp., East Hartford, Conn.

### STRESS ANALYSIS OF GAS TURBINE ENGINE STRUCTURES USING THE BOUNDARY ELEMENT METHOD

R. B. WILSON, D. W. SNOW (United Technologies Corp., Engineering Div., Hartaford, CT), and P. K. BANERJEE (New York, State University, Buffalo) IN: Advanced topics in boundary element analysis; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 45-63. refs

(Contract NAS3-23697)

The theory of the boundary element method is briefly reviewed with particular reference to the feasibility of elastic and inelastic three-dimensional stress analysis of complex structures characteristic of gas turbine engine components. Particular requirements of gas turbine analysis are defined, and examples of the use of a boundary element code designed for the three-dimensional stress analysis of turbine components are presented. It is shown that the general-purpose boundary element code can accurately and efficiently analyze many of the gas turbine engine structures. V.L.

**A86-34636**

### 757 MAJOR STATIC TEST INSTRUMENTATION SYSTEMS

J. P. WALLACE (Boeing Commercial Airplane Co., Seattle, WA) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 634-645.

Several instrumentation systems were designed and built to support the 757 Major Static Test Program. These systems included a 36 channel Sound Detection System, a 48 channel Inertia Detection System, an Airplane Attitude Display System and two large scale Data Acquisition and Display Systems capable of recording and displaying up to 1536 channels of data. Graphic displays were developed for plotting the test data on-line. CAD/CAM systems were used to produce strain gage location drawings. The supporting software that was developed and the graphic display systems resulted in significant cost savings over previous major test programs. Author

**A86-34639**

### PHOTOGRAMMETRY AS A MEANS OF MAPPING POSTBUCKLED COMPOSITE SURFACES

T. S. GATES (Rockwell International Corp., Los Angeles, CA) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 667-674. refs

Experimental results are discussed which indicate that nontopographic photogrammetry (NTP) can provide accurate, meaningful data for experimentally analyzing aspects of postbuckled structures. In particular, it is shown that the capability of NTP to supply data on initial imperfections, buckle geometry, edge effects, and transverse displacements exceeds the capability of moire or displacement transducers. By combining NTP with moire, strain gauges, and LDVTs, a complete and comprehensive data base can be formed to verify the analytical methodology required for efficient composite aircraft design. C.D.

**A86-34641**

### THE DEVELOPMENT OF A SYSTEM FOR THE STUDY OF FATIGUE CRACK GROWTH UP TO 2000 HZ

A. PETROVICH and W. BESSLER (Mechanical Technology, Inc., Latham, NY) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 682-687.

A system constructed for the study of fatigue crack growth under combined high/low cycle loading is described. Based on a voice coil electro-hydraulic servo-valve, the system was used to study fatigue crack growth in aircraft turbine disk alloy 718 under combined high and low cycle loading with a high cycle frequency up to 2000 Hz. A specimen was designed to minimize the frequency ranges over which dynamic stresses due to resonance are significant. The procedures for verifying the elimination of these dynamic stresses is described. The achievement of similar stress distributions over a range from 200 to 2000 Hz allowed observation of the frequency dependence of the transition from low cycle to high cycle dominated crack growth with varying high cycle stress intensity factor range. Author

**A86-34642**

### THE EFFECT OF CENTER DELAMINATION ON THE INSTABILITY OF COMPOSITE CYLINDRICAL PANELS

A. PALAZOTTO (USAF, Institute of Technology, Wright-Patterson AFB, OH) and G. SEIFERT IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 707-711. refs

The buckling loads of 8-ply graphite-epoxy delaminated cylindrical panels were determined experimentally. The study included two different ply orientations, two different aspect ratios (length/chord), two different delamination sizes, and one set of boundary conditions; clamped along the top and bottom edges and simply supported along the vertical sides. The experimental test results were compared to the linear bifurcation loads obtained from the STAGSC-1 finite element computer code and the buckling loads of panels with square cutouts which were also obtained from STAGSC-1. Author

**A86-35221**

**A WEIGHT METHOD FOR STRUCTUAL BOXES**

A. H. SCHMIDT (Boeing Vertul Co., Philadelphia, PA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 17 p. refs

(SAWE PAPER 1680)

A fast and relatively simple method is described to predict the weight of aluminum wing and tail structural boxes simultaneously loaded for bending and torsion. The basic data were derived from an extensive compression testing study on stiffened panels of NACA 24S-T and 75S-T aluminum (identifical to current use 2024-T3 and 7075-T6. There are two equations, one for Z-stiffened 24S-T, and one for 75S-T. A graphite composite material was estimated for one structural configuration using the ratios of the modulus of elasticity for aluminum and graphite and the aluminum stiffened sheet curves. The method, which has its primary application to subsonic aircraft, yields accurate results. As in most weight estimating methods, good judgement is required in selecting the values for the nonoptimum factor, the rib material factor, and the effective height factor. I.S.

**A86-35225**

**AN OPTIMIZATION PROCEDURE FOR A REDUNDANT WING STRUCTURE**

L. A. RIEDINGER (Northrop Corp., Advanced System Div., Pico Rivera, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 14 p.

(SAWE PAPER 1684)

A procedure is described whereby a minimum-weight wing may be obtained by calculating the optimum bending moment of inertia for each of the two spars (or boxes). This is accomplished by forcing each spar to support a proportionate amount of bending moment resulting in the maximum Mc/I stress equal to the damage tolerance allowable for the critical loading condition. The procedure described involves two initial analyses whereby an equation is obtained for the percent of bending in each spar as a function of the ratio of the moments of inertia. From this, a particular ratio of moments of inertia of the two spars is calculated to ensure that each spar is working to its allowable stress. According to the optimal stress theory, any other ratio would result in greater spar weight for bending. Three cases are used in the examples provided: constant height, same allowable stress; different heights, same allowable stress; and different heights, different materials; therefore, different allowable stresses. This procedure can save at least four weeks of design sizing iterations since it determines the optimum ratio of moments of inertia of the spars without iterations.

Author

**A86-35611**

**GEARBOX CONFIGURATION ANALYSIS**

H. COCKING (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 153-161. refs

In the design of any new gearbox, a conflict arises as to whether the gearbox should have an epicyclic or parallel shaft output stage. A method is derived which enables the relative merits of the two systems to be compared and the weight of each accurately predicted in the design stage. The method shows the actual relationship between the various gear design variables and the gear weight. A new factor called the 'configuration factor' is identified, which dominates the prediction of gearbox weight. It is shown how this factor is used to assess gearbox designs and identifies three features common to any low-weight gearbox. Finally, combining these features in a semiskeletal case results in an Advanced Engineering Gearbox, with a weight of only 62 percent of the current comparable gearbox. Author

**A86-35643**

**POSTBUCKLING AND CRIPPLING BEHAVIOR OF GRAPHITE/EPOXY THIN-WALLED AIRFRAME MEMBERS**

A. D. REDDY and L. W. REHFIELD (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 609-615. Research supported by the United Technologies Corp. refs

(Contract DAAG29-82-K-0094)

Test specimens employing plain-woven C3000 graphite/epoxy with five different ply layup geometries are the bases of the present study of buckling, postbuckling and crippling behavior in graphite/epoxy thin walled I-section airframe structure members. Boundary conditions at the web/flange interface, postbuckling stiffnesses, and the crippling loads and modes are determined. Nondimensional crippling curves are presented, on the basis of the preliminary data obtained, which may be used for predicting the crippling strengths of similar material systems; these curves are compared with existing ones for metals. O.C.

**A86-35651**

**ASSESSMENT OF STRUCTURAL DAMAGE IN COMPOSITES UTILIZING ACOUSTIC EMISSION TECHNOLOGY**

W. C. BOYCE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and R. K. MILLER (United Technologies Research Center, East Hartford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 665-677. refs

AE can be used in the quantitative characterization of structural damage in composite structures by means of a nonresonant point contact transducer (PCT), together with broadband signal processing; experimental results thus obtained have revealed unique signatures for matrix failures, delaminations, and fiber breaks. Attention is presently given to the development status and prospects for the application of PCT-based AE to full scale fatigue testing of helicopter dynamic components, as well as to the development of signal processing algorithms for the evaluation and tracking of structural damage propagation in composites.

O.C.

**A86-35658**

**ADVANCED STRUCTURAL CASTING APPLICATIONS FOR A GAS TURBINE ENGINE**

E. F. BISHOP, J. N. FLECK, and T. M. REGAN (General Electric Co., Lynn, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 777-784.

Attention is given to the methods and results of a program to convert complex gas turbine engine structural elements into precision castings that do not compromise design function, weight, and performance characteristics. Significant cost reductions are noted to result from the obviation of materials and labor otherwise required for fabrication by other means; welding, brazing and other joining operations are eliminated, and the inventory of components and subassemblies is reduced. Illustrative examples are noted in the case of the T700 gas turbine helicopter engine family's investment castings. O.C.

**A86-35659**

**APPLICATION OF CLOSED-LOOP MACHINING IN THE MANUFACTURE OF GAS TURBINES**

S. M. BURGESS and M. H. WOLLOWITZ (General Electric Co., Aircraft Engine Business Group, Lynn, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 785-791.

The in-process adaptive control system designated 'closed loop machining' (CLM), which employs machine-mounted probes to automatically correct process and machine errors, is presently applied to the manufacture of gas turbine components to reduce both manufacturing losses and product costs. The CLM system is incorporated into computer numerical control lathes. Attention is given to hardware concepts used in implementation, as well as to software design and programming requirements. The sources of probing system errors are discussed, together with comments on CLM systems obtained from machine operators, numerical control programmers, and production managers. O.C.

**A86-35660**

### ROBOTICS IN AIRCRAFT MANUFACTURING

J. J. BARTO, JR. (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 793-800.

Attention is given to two robotic installations for the manufacture of helicopter airframe components: a small hole-drilling and deburring system, an assembly system for drill/wet-seal/rivet operations. The multistation drilling system employs a robot to drill pilot holes in a family of machined aluminum cabin frame structures, and also brush-deburrs the machined surfaces. The assembly system involves a track-mounted robot designed to drill, wet-seal, and rivet Kevlar and aluminum panels onto preassembled frames that are positioned in a work cell arrangement. O.C.

**A86-35980**

### THE EFFECT OF THE ELECTRODE GAP GEOMETRY ON CURRENT DISTRIBUTION DURING ELECTROCHEMICAL ROUNDING OF EDGES [VLIIANIE GEOMETRII MEZHELEKTRODNOGO PROMEZHUTKA NA RASPREDELENIE TOKA PRI ELEKTROKHIMICHESKOM SKRUGLENII KROMOK]

IU. M. VAKHITOV and A. KH. KARIMOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 20-24. In Russian.

In order to increase the reliability and life of gas-turbine engines it is necessary that sharp edges on some parts be rounded and then polished. The objective of the present study was to investigate the possibility of controlling current density by varying the shape and size of the working surface of the electrode tool and of the insulating screen during the electrochemical rounding of edges. Analog modeling using an electrointegrator has made it possible to obtain a number of practical recommendations concerning the design of the electrode tool and instrumentation. V.L.

**A86-35997**

### USING THE PERTURBATION METHOD FOR DETERMINING THE DIE FORGING PARAMETERS FOR AIRCRAFT PARTS [ISPOL'ZOVANIE METODA VOZMUSHCHENII PRI OPREDELENII TEKHNOLOGICHESKIKH PARAMETROV SHTAMPOVKI AVIATSIONNYKH DETALEI]

I. P. POPOV and V. D. MASLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 93-96. In Russian.

The perturbation method with a series expansion of the solution in powers of the small operator is used to obtain simple analytical expressions for determining the principal process variables for the die forging of aircraft parts. The changes in the thickness of the part during the die forging operation are described in the form of a power-law function with allowance for the hardening of the material on the basis of the energy criterion of plasticity. The approach proposed here is demonstrated through an example. V.L.

**A86-35998**

### THE POSSIBILITY OF USING ION IMPLANTATION FOR INCREASING THE LIFE OF THE COMPRESSOR BLADES OF GAS-TURBINE AIRCRAFT ENGINES [O VOZMOZHNOSTI ISPOL'ZOVANIIA IONNOI IMPLANTATSII DLIA POVYSHENIIA DOLGOVECHNOSTI LOPATOK KOMPRESSORA GAZOTURBINNYKH AVIATSIONNYKH DVIGATELEI]

A. V. FEDOROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 96, 97. In Russian.

**A86-35999**

### SOME CHARACTERISTICS OF STRUCTURE FORMATION IN FORGED SEMIFINISHED PRODUCTS OF V93PCH ALUMINUM ALLOY [O NEKOTORYKH ZAKONOMERNOSTIAKH FORMIROVANIIA STRUKTURY V KOVANYKH POLUFABRIKATAKH IZ ALIUMINIEVOGO SPLAVA V93PCH]

A. IA. CHERNIAK, E. L. SHIF, and A. G. KARAKOZOVA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 97-99. In Russian.

The formation of a local coarse-grained structure in forged semifinished products of V93pch, an Al-Zn-Mg-Cu alloy commonly used in aircraft engineering, is investigated as a function of the structure of the alloy (polygonized or recrystallized) prior to the final stage of forging, temperature, and the extent of deformation. It is found that the formation of coarse-grained zones in V93pch alloy is largely due to the nonuniformity of deformation and to the excessively wide temperature range of forging. In order to obtain a sufficiently fine-grained recrystallized structure, it is recommended that the temperature of the final stage of forging do not exceed 610 K. V.L.

**A86-36176**

### SOME ASPECTS OF VARIABILITY IN FATIGUE CRACK INITIATION AND PROPAGATION IN THICK ALUMINIUM ALLOY SECTIONS

J. Y. MANN, R. A. PELL, and A. S. MACHIN (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) International Journal of Fatigue (ISSN 0142-1123), vol. 8, April 1986, p. 59-66. refs

As part of an investigation to extend the lives of wings of the Mirage IIIO aircraft, a fatigue testing program and extensive fractographic examination was undertaken on thick specimens representing the critical section of the spar to provide information on variability in fatigue crack initiation and propagation. A good linear relationship was found between the log life and log crack depth for individual specimens. At the smallest crack depth used for analysis (0.3 mm) no significant differences were found between the standard deviations of log life to crack initiation, for propagation or to final failure, nor in the corresponding standard deviations of arithmetic lives. However, in considering the more general question of whether the greater contribution to variability in total life comes from that in initiation life or that in propagation life, it is shown that account must be taken of the analytical basis of the assessment - whether arithmetic or logarithmic. Author

**A86-36805**

### THERMAL SCENE GENERATORS

A. PRITCHARD (British Aerospace, PLC, Research Dept., Bristol, England) Aerospace Dynamics (ISSN 0263-2012), vol. 18, Winter 1986, p. 17-22.

Design and performance features are discussed for Thermal Scene Generators (TSG) for hardware flight simulation testing of heat seeking missiles. The TSG must match the seeker's field of view, have a suitable range and resolution for the seeker design envelope, and have a response speed suitable for the trials run. The Bly cell, a thin membrane with favorable light absorption, thermal conductivity and emissivity properties, can be image-heated in a vacuum to a temperature corresponding to a visible image. A massive monolithic transducer can be employed to provide closed loop moving imagery through resistance heating. Sample imagery and circuitry diagrams are provided from experimental testing of the latter method by means of the application of thin film hybrid technology. M.S.K.

**A86-36887#**
**ON THE METHODOLOGY OF AN INTERACTIVE COMPUTER-AIDED OPTIMAL DESIGN OF A DUAL-VALVE LINKAGE**
D. E. ARMY, JR. (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), R. C. AZAR, and S. CHANDRASHEKHAR (Western New England College, Springfield, MA) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 339-345. refs

This paper presents a methodology for obtaining a set of on-line optimal dual-valve linkages using an interactive computer-aided design approach. The dual-valve linkage is used in aircraft environmental systems wherein airflow in two ducts is controlled using a common valve actuator. The throttle and the bypass valves must open or close a desired amount according to a design schedule, so an efficient synthesis method has to be employed. A least-squares method along with Freudenstein's equation is used to minimize an objective function and thereby reduce the difference between the desired output and the measured output over the domain of operation. The software package developed enables a user to interact with the computer to determine a number of alternative designs depending upon the weight, the torque ratios and the effective valve area. This allows the user to choose from a number of options in a relatively short period of time and thus significantly reduce the design time. Author

**A86-37067*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**IMPLICIT, VECTORIZABLE SCHEMES FOR THE FLUX-DIFFERENCE SPLIT, THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS**
C. H. LIU, P.-M. HARTWICH, and C.-H. HSU (NASA, Langley Research Center, Hampton, VA) Chinese Aerodynamics Research Society, International Conference on Numerical Methods in Fluid Dynamics, 10th, Beijing, People's Republic of China, June 23-27, 1986, Paper. 4 p. refs

Two hybrid upwind models are defined for solving the Euler equations. The algorithms both employ approximate factorization (AF) in crossplane and symmetric block Gauss-Seidel relaxation in the third direction. One approach adds an additional factorization step to lower the number of required grid point operations for inversion of the block tridiagonal matrices; however, the move permits only one third of the operations to be vectorized. Finite difference solutions are calculated on a C-H-type grid, in this case enveloping a slender, sharp-edged delta wing. Sample data are provided for the calculated vortex flow for Re of 10,000, at a 20.5 deg angle of attack, represented in a crossflow velocity vector plot and in a spanwise pressure coefficient distribution. The AF scheme, without additional factorization, when used with a grid covering 51 x 51 x 72 points provides a convergent solution with no time step lasting longer than 0.00001 sec. M.S.K.

**A86-37071*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
**CHARACTERISTICS PERTAINING TO A STIFFNESS CROSS-COUPLED JEFFCOTT MODEL**
K. L. SPANYER (NASA, Marshall Space Flight Center, Huntsville, AL) ASME, Conference and Exhibit on Mechanical Vibration and Noise, Cincinnati, OH, Sept. 10-13, 1985. 12 p. refs
(ASME PAPER 85-DET-144)

Rotordynamic studies of complex systems utilizing multiple degree-of-freedom analysis have been performed to understand response, loads, and stability. In order to understand the fundamental nature of rotordynamic response, the Jeffcott rotor model has received wide attention. The purpose of this paper is to provide a generic rotordynamic analysis of a stiffness cross-coupled Jeffcott rotor model to illustrate characteristics of a second order stiffness-coupled linear system. The particular characteristics investigated were forced response, force vector diagrams, response orbits, and stability. Numerical results were achieved through a fourth order Runge-Kutta method for solving differential equations and the Routh Hurwitz stability criterion. The numerical results were verified to an exact mathematical solution for the steady state response. Author

**A86-37072*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**TECHNIQUES FOR INCREASING THE UPDATE RATE OF REAL-TIME DYNAMIC COMPUTER GRAPHIC DISPLAYS**
W. M. KAHLBAUM, JR. (NASA, Langley Research Center, Hampton, VA) Association for Computing Machinery, SIGGRAPH 86, Dallas, TX, Aug. 18-22, 1986, Paper. 22 p.

This paper describes several techniques which may be used to increase the animation update rate of real-time computer raster graphic displays. The techniques were developed on the ADAGE RDS 3000 graphic system in support of the Advanced Concepts Simulator at the NASA Langley Research Center. The first technique involves pre-processing of the next animation frame while the previous one is being erased from the screen memory. The second technique involves the use of a parallel processor, the AGG4, for high speed character generation. The description of the AGG4 includes the Barrel Shifter which is a part of the hardware and is the key to the high speed character rendition. The final result of this total effort was a four fold increase in the update rate of an existing primary flight display from 4 to 16 frames per second. Author

**A86-37091*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**THE DEVELOPMENT OF LASER SPECKLE VELOCIMETRY FOR THE MEASUREMENT OF VORTICAL FLOW FIELDS**
C. A. SMITH (NASA, Ames Research Center, Moffett Field, CA), L. M. M. LOURENCO, and A. KROTHAPALLI (Florida State University, Tallahassee) AIAA, Aerodynamic Testing Conference, 14th, West Palm Beach, FL, Mar. 5-7, 1986. 15 p. refs
(AIAA PAPER 86-0768)

A new velocity measurement technique is described that provides the simultaneous visualization of a two-dimensional streamline pattern and the quantification of the velocity field. The main advantage of this technique is that the velocity field can be measured with sufficient accuracy and spatial resolution so that the vorticity field can be readily obtained. This technique is ideally suited for the study of unsteady vortical flows, which occur in rotorcraft and in high-angle-of-attack aerodynamics. The technique, some of the important parameters that affect its use, and some recent examples are described. Author

**A86-37106**
**THE MATERIAL DEVELOPMENT, COMPONENT MANUFACTURE AND POST-SERVICE EVALUATION OF RB 211-524 COWL DOORS UTILISING CARBON FIBRE COMPOSITE MATERIALS**
G. A. OWENS (Rolls-Royce, Ltd., Derby, England) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 83-99. refs

**A86-37112**
**POSTBUCKLING FAILURE OF COMPOSITE PANELS**
N. BUSKELL, G. A. O. DAVIES, and K. A. STEVENS (Imperial College of Science and Technology, London, England) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 290-314. Sponsorship: Ministry of Defence. refs
(Contract MOD-2037/0230/XR/STR)

A series of postbuckling tests have been conducted on thin rectangular quasi-isotropic CFRP panels. The testing machine allowed careful control of panel loading and by using acoustic emission as a diagnosis it was possible to monitor the onset and progress of failure before compression collapse destroyed the evidence. The panels exhibited substantial postbuckled strength, safely supporting at least twice their buckling load. Inspection of damaged panels revealed that postbuckling failure was caused by the rapid growth of edge delamination from positions corresponding to a node line in the buckled mode shape. Author

**A86-37119**
**DAMAGE TOLERANT COMPOSITE DESIGN DEVELOPMENT**
E. DEMUTS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and R. E. HORTON (Boeing Co., Seattle, CA) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 427-439. USAF-sponsored research. refs

A design development has been presented of a damage tolerant composite multirib wing structural box section. A gradual advancing of the design through testing, evaluation of results and potential design modification at various specimen complexity levels has been applied here. This traditional building block approach is found to be valid and valuable. The specimen complexity levels include flat, simple coupons of a wide range of sizes and built-up wing cover panels with three and five stiffeners. The design development tests have demonstrated adequate damage tolerance of the blade-stiffened and the RTD I-stiffened designs. Findings from investigation of a premature fatigue failure of a moisture preconditional I-stiffened panel may cause its design modification. This design is used in the large box component whose tests are to qualify the component design and verify the composite damage tolerance requirements applied in designing the box. Author

**N86-24883#** Army Aviation Systems Command, St. Louis, Mo.
**VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS (UH-1 TAIL WHIP AND CABIN ROOF BENT WHIP EVALUATION)**
J. CARALYUS, J. MILLER, C. GRATACOS, and F. CANSLER Dec. 1985 103 p refs
(AD-A163561; USAAVSCOM-TR-85-E-3) Avail: NTIS HC A06/MF A01 CSCL 17B

The American Electronics Laboratory (AEL), Allaire, NJ, was tasked by the U.S. Army Avionics Research and Development Laboratory (SAVAA-M), Fort Monmouth, NJ, to develop replacement breadband matching modules for the CU-942B and the FM 10-30-1 antenna to satisfy specified requirements for Project SINCGARS. AEL was further tasked to test various candidate antennas provided by commercial vendors that are mechanically interchangeable with the CU-942B and the FM 10-30-1. After completion of the AEL development/test program, AVRADA tasked an independent, non-based Government antenna test facility to conduct prescribed antenna verification tests in accordance with an agreed upon test plan. This technical report describes communications antenna systems provided by Dayton-Granger, Inc (DGI), American Electronics Lab (AEL), and Avionics Antenna Systems (AVANT). The test measurements were conducted at the Naval Air Development Center, Antenna Test Facility located in Warminster, PA. The information in this report provides, in part, the technical data for the protection data package of adequate VHF-FM Communications antennas for the UH-1 helicopter when used with the new SINCGARS Radio. Author (GRA)

**N86-24897#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**REAL-TIME FLIGHT TEST PCM DATA ACQUISITION MONITOR M.S. Thesis**
J. R. CROASDALE Sep. 1985 268 p refs
(AD-A164035; AFIT/GE/ENG/85S-1) Avail: NTIS HC A12/MF A01 CSCL 17B

A computer based system utilizing an inexpensive off-the-shelf personal computer and original interface design centered around a 68000 microprocessor for real-time monitoring of a time division multiplexed pulse code modulated (TDM/PCM) data stream was designed and constructed. This system is a prototype of a low-cost, portable PCM data acquistion monitor intended for use in flight test programs by the 4950th Test Wing at Wright-Patterson AFB, Oh. It will accept a single Armed Forces Instrumentation Standard NRZ or split-phase (Manchester) baseband data stream at rates up to 100 KBPS, display selected data words in graphical or numerical format, and alarm the user when data exceeds certain limits. It will provide a real-time verification that the data being generated and recorded during a test is of acceptable quality, allowing the option of continuation of the test, or termination. The system is capable of automatically determining the data rate and signaling format and synchronizing itself with the incoming signal. GRA

**N86-24934*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**UNSTEADY HEAT TRANSFER AND DIRECT COMPARISON TO STEADY-STATE MEASUREMENTS IN A ROTOR-WAKE EXPERIMENT**
J. E. OBRIEN, R. J. SIMONEAU, J. E. LAGRAFF (Syracuse Univ.), and K. A. MOREHOUSE Jan. 1986 21 p refs Presented at the 8th International Heat Transfer Conference, San Francisco, Calif., 17-22 Aug. 1986
(NASA-TM-87220; E-2757; NAS 1.15:87220) Avail: NTIS HC A02/MF A01 CSCL 20D

Circumferentially local and time-resolved heat transfer measurements were obtained for a circular cylinder in crossflow located downstream of a rotating spoked wheel wake generator in a steady flow tunnel. The unsteady heat transfer effects were obtained by developing an extension of a thin film gauge technique employed to date exclusively in short-duration facilities. The time-average thin film results and conventional steady-state heat transfer measurements were compared. Time-averaged wake-induced stagnation heat transfer enhancement levels above the nowake case were about 10% for the four cylinder Reynolds numbers. This enhancement level was nearly independent of bar passing frequency and was related directly to the time integral of the heat transfer spikes observed at the bar passing frequency. It is observed that the wake-induced heat transfer spikes have peak magnitudes averaging 30 to 40% above the interwake heat transfer level. E.A.K.

**N86-24936#** National Aeronautics and Space Administration, Washington, D.C.
**AN EXPERIMENTAL INVESTIGATION ON LOCATION OF BOUNDARY LAYER TRANSITION ON THE NACA 0012 USING SURFACE HOT FILM GAGES**
T. C. WANG Mar. 1986 10 p refs Transl. into ENGLISH from Acta Aeronautica et Astronautica Sinica, v. 5, no. 4, Dec. 1984 p 401-405 Original language document was announced in IAA as A85-43231 Transl. by SCITRAN, Inc., Santa Barbara, Calif. Original doc. was prep. by Nanjing Aeronautical Inst.
(Contract NASW-4004)
(NASA-TM-88285; NAS 1.15:88285) Avail: NTIS HC A02/MF A01 CSCL 20D

Hot film gages were attached flush to the upper surface of a NACA-type 0012 airfoil in order to locate the boundary layer transitions corresponding to a range of distances from the leading edge. The measurements were carried out in a low-speed wind tunnel at Nanjing Aeronautical Institute. During the wind-tunnel tests, Reynolds numbers were kept constant at 200,000 Re(b), while the angle of attack of the airfoil was varied continuously. The locations on the airfoil of boundary layer separation and turbulent boundary layer attachment are shown in a diagram. It is found that the location of boundary layer transitions using hot film gages is a feasible and practical technique. Author

**N86-24944#** Department of the Air Force, Washington, D.C.
**DUAL MODE HEAT EXCHANGER Patent Application**
F. E. ALTOZ, inventor (to Air Force) 3 Dec. 1985 18 p refs
(AD-D012156; US-PATENT-APPL-SN-804193) Avail: NTIS HC A02/MF A01 CSCL 20M

The invention comprises a compact, light weight, dual mode heat transfer device. The dual mode heat transfer device provides for air cooling of heat dissipating electronic components at moderate aircraft speeds and when available ambient air is below a preselected temperature. At elevated aircraft speeds when the ambient air temperature is above the preselected temperature a coolant liquid is converted to steam or vapor in order to cool the heat dissipating electronic components. A preferred embodiment of the invention includes a cold plate for conducting heat away from the heat dissipating components and radiator fins for dissipating cold plate heat to a air cooling flow. GRA

**N86-24955*#** Kansas Univ. Center for Research, Inc., Lawrence.
**REVIEW AND EVALUATION OF RECENT DEVELOPMENTS IN MELIC INLET DYNAMIC FLOW DISTORTION PREDICTION AND COMPUTER PROGRAM DOCUMENTATION AND USER'S MANUAL ESTIMATING MAXIMUM INSTANTANEOUS INLET FLOW DISTORTION FROM STEADY-STATE TOTAL PRESSURE MEASUREMENTS WITH FULL, LIMITED, OR NO DYNAMIC DATA Final Report**
W. G. SCHWEIKHARD and S. R. DENNON Apr. 1986 257 p refs
(Contract NAG3-11)
(NASA-CR-176765; NAS 1.26:176765) Avail: NTIS HC A12/MF A01 CSCL 20D

A review of the Melick method of inlet flow dynamic distortion prediction by statistical means is provided. These developments include the general Melick approach with full dynamic measurements, a limited dynamic measurement approach, and a turbulence modelling approach which requires no dynamic rms pressure fluctuation measurements. These modifications are evaluated by comparing predicted and measured peak instantaneous distortion levels from provisional inlet data sets. A nonlinear mean-line following vortex model is proposed and evaluated as a potential criterion for improving the peak instantaneous distortion map generated from the conventional linear vortex of the Melick method. The model is simplified to a series of linear vortex segments which lay along the mean line. Maps generated with this new approach are compared with conventionally generated maps, as well as measured peak instantaneous maps. Inlet data sets include subsonic, transonic, and supersonic inlets under various flight conditions. Author

**N86-24984** Department of the Air Force, Washington, D.C.
**LASER BEAM DUCT PRESSURE CONTROLLER SYSTEM Patent**
A. J. LADERMAN, inventor (to Air Force) and F. M. BERGTHOLD, JR., inventor (to Air Force) 3 Sep. 1985 5 p
(AD-D012017; US-PATENT-4,538,635;
US-PATENT-APPL-SN-539352; US-PATENT CLASS-137-114)
Avail: US Patent and Trademark Office CSCL 20D

Disclosed is a laser beam duct pressure controller system for maintaining a spatially uniform pressure in a flowing gas volume which is subjected to temporal pressure variations. This desired result is accomplished with cooperating structural components (and gases therein), which eliminate the axial flow of a conditioning gas within the laser beam duct by matching the time rate of change of the pressure of the flowing conditioning gas to the time rate of change of the pressure in the cavity of an operably associated laser beam turret. GRA

**N86-24990*#** Akron Univ., Ohio. Dept. of Mechanical Engineering.
**SYSTEM LIFE AND RELIABILITY MODELING FOR HELICOPTER TRANSMISSIONS Final Report**
M. SAVAGE and C. K. BRIKMANIS Washington Apr. 1986 202 p refs
(Contract NAG3-55)
(NASA-CR-3967; E-2889; NAS 1.26:3967) Avail: NTIS HC A10/MF A01 CSCL 05C

A computer program which simulates life and reliability of helicopter transmissions is presented. The helicopter transmissions may be composed of spiral bevel gear units and planetary gear units - alone, in series or in parallel. The spiral bevel gear units may have either single or dual input pinions, which are identical. The planetary gear units may be stepped or unstepped and the number of planet gears carried by the planet arm may be varied. The reliability analysis used in the program is based on the Weibull distribution lives of the transmission components. The computer calculates the system lives and dynamic capacities of the transmission components and the transmission. The system life is defined as the life of the component or transmission at an output torque at which the probability of survival is 90 percent. The dynamic capacity of a component or transmission is defined as the output torque which can be applied for one million output shaft cycles for a probability of survival of 90 percent. A complete summary of the life and dynamic capacity results is produced by the program. Author

**N86-24991*#** Irwin (Arthur S.) Co., Inc., Bemus Point, N.Y.
**REVIEW AND CRITICAL ANALYSIS: ROLLING-ELEMENT BEARINGS FOR SYSTEM LIFE AND RELIABILITY Final Report**
A. S. IRWIN, W. J. ANDERSON, and W. J. DERNER Mar. 1985 234 p
(Contract NAS3-23520)
(NASA-CR-174710; NAS 1.26:174710; USAAVSCOM-TR-85-F-1)
Avail: NTIS HC A11/MF A01 CSCL 13I

A ball and cylindrical roller bearing technical specification which incorporates the latest state-of-the-art advancements was prepared for the purpose of improving bearing reliability in U.S. Army aircraft. The current U.S. Army aviation bearing designs and applications, including life analyses, were analyzed. A bearing restoration and refurbishment specification was prepared to improve bearing availability. Author

**N86-24992*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**TESTING OF YUH-61A HELICOPTER TRANSMISSION IN NASA LEWIS 2240-KW (3000-HP FACILITY**
A. M. MITCHELL, F. B. OSWALD, and F. T. SCHULLER Mar. 1986 28 p refs
(NASA-TP-2538; E-2801; NAS 1.60:2538) Avail: NTIS HC A03/MF A01 CSCL 01C

A helicopter transmission that was being considered for the Army's Utility Tactical Transport Attack System (UTTAS) was tested in the NASA Lewis 2240-kW (3000-hp) test facility to obtain the transmission's operational data. The results will form a vibration and efficiency data base for evaluation similar-class helicopter transmissions. The transmission's mechanical efficiency was determined to be 98.7 percent at its rated power level of 2080 kW (2792 hp). At power levels up to 113 percent of rated the transmission displayed 56 percent higher vibration acceleration levels on the right input than on the left input. Both vibration signature analysis and final visual inspection indicated that the right input spiral-bevel gear had poor contact patterns. The highest vibration meter level was 52 g's rms at the accessory gear, which had free-wheeling gearsets. At 113 percent power and 100 percent rated speed the vibration meter levels generally ranged from 3 to 25 g's rms. Author

**N86-24997#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**AUTOMATING KNOWLEDGE ACQUISITION IN A FLIGHTLINE ROBOT M.S. Thesis**
W. M. CLIFFORD Dec. 1985 170 p refs
(AD-A163829; AFIT/GE/ENG/85D-7) Avail: NTIS HC A08/MF A01 CSCL 06D

Robots enjoy widespread use in industry on simplistic repetitive tasks in a controlled environment. Tasks in the military domain, particularly the flightline, require mobility and intelligence. While the mobility issue is being addressed, the intelligence issue is not. By giving the robot the ability to learn from a novice, the robot could be placed on the flightline and learn what it needs to know from the domain experts. Rather than deal with a toy problem, this work takes the actual refueling Job Guides for two aircraft and shows how these can be used directly by a computer. The process involves three steps. First, the text is transformed into a common natural language processor form. Second, the forms are examined to allow the commonalty between the two refueling tasks to be extracted. The forms are expanded by applying expert system and planning techniques to include missing domain and world

knowledge. Finally, the forms are examined to allow the commanalty between the two refueling tasks to be extracted.
GRA

**N86-25003*#** Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
**LIFE PREDICTION AND CONSTITUTIVE MODELS FOR ENGINE HOT SECTION ANISOTROPIC MATERIALS PROGRAM Annual Status Report**
G. A. SWANSON, I. LINASK, D. M. NISSLEY, P. P. NORRIS, T. G. MEYER, and K. P. WALKER Feb. 1986 203 p refs
(Contract NAS3-23939)
(NASA-CR-174952; NAS 1.26:174952; PWA-5968-19) Avail: NTIS HC A09/MF A01 CSCL 14D

This report presents the results of the first year of a program designed to develop life prediction and constitutive models for two coated single crystal alloys used in gas turbine airfoils. The two alloys are PWA 1480 and Alloy 185. The two oxidation resistant coatings are PWA 273, an aluminide coating, and PWA 286, an overlay NiCoCrAlY coating. To obtain constitutive and/or fatigue data, tests were conducted on coated and uncoated PWA 1480 specimens tensilely loaded in the 100 , 110 , 111 , and 123 directions. A literature survey of constitutive models was completed for both single crystal alloys and metallic coating materials; candidate models were selected. One constitutive model under consideration for single crystal alloys applies Walker's micromechanical viscoplastic formulation to all slip systems participating in the single crystal deformation. The constitutive models for the overlay coating correlate the viscoplastic data well. For the aluminide coating, a unique test method is under development. LCF and TMF tests are underway. The two coatings caused a significant drop in fatigue life, and each produced a much different failure mechanism.
Author

**N86-25371#** Royal Aircraft Establishment, Farnborough (England). Propulsion Dept.
**CRACK GROWTH IN NEAR-ALPHA TITANIUM ALLOYS**
C. R. GOSTELOW *In* AGARD Damage Tolerance Concepts for Critical Engine Components 5 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Ever since the first gas turbine aero engine entered into service there has been pressure to develop more powerful yet more efficient and lightweight units. To this end manufacturers have endeavored to increase overall pressure ratios and maximum cycle temperatures while trying to limit engine size by using materials having higher strength-to-weight ratios and higher temperature capability. Two main material approaches were followed in order to help meet these requirements. These are the development of high strength, high temperature capability nickel base superalloys for extensive use in the turbine and the replacement of heavy steels and nickel alloys in the compressor by advanced lightweight titanium alloys. The latter approach was the driving force behind the development in the UK of a unique range of creep-resistant near-alpha titanium alloys suitable for use up to 600 C. A variety of parameters are described which can influence the crack growth characteristics of near-alpha titanium alloys, with particular reference to the UK alloy IMI685. The relevance of these laboratory data to actual engine operation is assessed.
Author

**N86-25373#** Fiat Research Center, Orbassano, Turin (Italy).
**SMALL DEFECT CHARACTERIZATION IN POWDER METALLURGY MATERIALS**
S. R. FIORENTIN and H. WALTHER (Fiat Aviazione S.p.A., Turin, Italy) *In* AGARD Damage Tolerance Concepts for Critical Engine Components 12 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Powder metallurgy nickel base superalloys are becoming important structural materials for the manufacturing of critical complex-shaped aircraft components (e.g. turbine disks). Since fatigue life is largely affected by the presence of defects, in order to extend the limit of application of PM materials as far as possible, the need is felt for a nondestructive technique capable of detecting defects of size down to approximately 50 micrometers. An ultrasonic technique is presented which allows the detection and characterization of such small defects. It is based on the analysis of the signals backscattered by the material lying in the focal region of a short pulse transducer. During a first overall inspection of the component a real time data processing allows both the detection of critical defects and the evaluation of average grain size. In successive local inspections, confined in the regions where inclusions have been detected, further information on their characteristics may be collected. Some experimental results obtained on powder metallurgy samples containing seeded inclusions are presented.
Author

**N86-25375#** TRW, Inc., Cleveland, Ohio.
**MULTIAXIAL AND THERMOMECHANICAL FATIGUE CONSIDERATIONS IN DAMAGE TOLERANT DESIGN**
G. E. LEESE and R. C. BILL (Army Research and Technology Labs., Cleveland, Ohio) *In* AGARD Damage Tolerance Concepts for Critical Engine Components 17 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

In considering damage tolerant design concepts for gas turbine hot section components, several challenging concerns arise: Complex multiaxial loading situations are encountered; thermomechanical fatigue loading involving very wide temperature ranges is imposed on components; some hot section materials are extremely anisotropic; and coatings and environmental interactions play an important role in crack propagation. The effects of multiaxiality and thermomechanical fatigue are considered from the standpoint of their impact on damage tolerant design concepts. Recently obtained research results as well as results from the open literature are examined and their implications for damage tolerant design are discussed. Three important needs required to advance analytical capabilities in support of damage tolerant design become readily apparent: (1) a theoretical basis to account for the effect of nonproportional loading (mechanical and mechanical/thermal); (2) the development of practical crack growth parameters that are applicable to thermomechanical fatigue situations; (3) the development of crack growth models that address multiple crack failures.
Author

**N86-25380#** National Aerospace Lab., Amsterdam (Netherlands).
**TURBISTAN: A STANDARD LOAD SEQUENCE FOR AIRCRAFT ENGINE DISCS**
A. J. A. MOM, W. J. EVANS (Royal Aircraft Establishment, Farnborough, England), and A. A. TENHAVE *In* AGARD Damage Tolerance Concepts for Critical Engine Components 12 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

The development of TURBISTAN is a joint international effort to derive a loading standard representative for fighter aircraft engine disc usage. A representative loading standard offers considerable potential advantages over the present zero-max type of loading used for disc material evaluation. This is because the standard incorporates the effects of subcycles, their number, magnitude and sequence, which are known to seriously affect disc life and for which current life prediction techniques only partly account. Therefore usage of the standard in fatigue tests provides an improved evaluation of material properties, structural details, fabrication techniques, surface quality and life prediction. The compilation of operational flight data is described along with their analysis and the the generation of a preliminary TURBISTAN sequence for 'cold' compressor discs. The sequence contains about 8000 cycles which represent 100 flights. In addition, the background and philosophy of a material testing program meant to assess the effectiveness of the standard and to explore the validity of the assumptions made in its derivation is described.
Author

**N86-25381#** Rolls-Royce Ltd., Derby (England).
**AN ANALYSIS OF RIG TEST DISC FAILURES**
G. ASQUITH *In* AGARD Damage Tolerance Concepts for Critical Engine Components 10 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

A major objective in gas turbine engineering is the design and manufacture of discs that are reliable in service. Much depends on the accurate prediction of safe total lives and inspection intervals. Accurate predictions come from a complete understanding of material behavior involving experimentation, interpretation and quantification, for which a balanced program of laboratory specimen and full sized disc evaluation is required. Cyclic testing of full size discs is essential, this allows each disc to do its own 'Monte Carlo' evaluation of the large number of variables that affect the final result. Where life can be predictd entirely by linear elastic fracture mechanics some simplification can be introduced; this encourages studies in the quantification of short crack propagation behavior. Author

**N86-25555#** Joint Publications Research Service, Arlington, Va.
**NORMAL FORCE CHARACTERISTICS OF SHARP NOSED BODIES OF REVOLUTION AT HIGH ANGLES OF ATTACK IN SUBSONIC AND TRANSONIC FLOW Abstract Only**
X. TU and W. WU *In its* China Report: Science and Technology (JPRS-CST-86-011) p 102 31 Mar. 1986 Transl. into ENGLISH from Kongqidonglixue Xuebao (Mianyang, China), no. 4, 1985 p 81-89
Avail: NTIS HC A07/MF A01

The normal force characteristics of sharp nosed bodies of revolution were investigated experimentally at high angles of attack in a Mack number range form 0.35 to 1.20. The test results were analyzed. It was shown that both the Mach number and the Reynolds number strongly influence the normal force characteristics. The calculation methods based on crossflow theory had not taken into account the effects of viscosity and compressibility, so the actual phenomenon could not be represented. The present research also investigated the effect of rolling orientation on the normal force characteristics experimentally. It was shown that the vortex pattern on the leeside surface has a considerable effect on the normal force coefficient. The difference of the normal force coefficient for different rolling orientations is approximately the same as the magnitude of the Mack number effect. For sharp nosed bodies of revolution the vortex pattern on the leeside surface cannot be predicted precisely. For the same model, at the same angle of attack, the vortex pattern is different with different rolling orientations. Therefore, we can predict that the aerodynamic characteristics of sharp nosed bodies of revolution at high angles of attack should not be unique, and they can vary within a certain range. Author

**N86-25600#** Joint Publications Research Service, Arlington, Va.
**AN-124 AIRPLANE'S CARGO-HANDLING AND AUTOMATION EQUIPMENT**
T. KUZNETSOVA *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 1-2 7 Feb. 1986 Transl. into ENGLISH from Pravda Ukrainy (Kiev, USSR), 26 May 1985 p 1
Avail: NTIS HC A06/MF A01

Development of the wide-body transport aircraft AN-124 is described. The aircraft has a large payload capacity, an airspeed of 800 to 850 kilometers an hour at an altitude of 10 to 12 kilometers, one third the fuel consumption, and the ability to use runways that are not concrete. The AN-124 is equipped with the latest navigation and piloting equipment, as well as an automated electrohydromechanical control system with quadruple redundancy, which ensures a high degree of reliability. The aircraft is also equipped with an onboard automatic monitoring complex which oversees all parameters, runs a comparison check, and warns ground services in the event of a malfunction. B.G.

**N86-25793*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**GENERATION OF SPIRAL BEVEL GEARS WITH ZERO KINEMATICAL ERRORS AND COMPUTER AIDED TOOTH CONTACT ANALYSIS**
F. L. LITVIN (Illinois Univ., Chicago.), W. J. TSUNG, J. J. COY, and C. HEINE (Dana Corp., Fort Wayne, Ind.) Mar. 1986 21 p refs Presented at the 2nd World Congress on Gearing, Paris, France, 2-5 Mar. 1986
(Contract NAG3-48)
(NASA-TM-87273; E-2932; NAS 1.15:87273; USAAVSCOM-TR-86-C-2) Avail: NTIS HC A02/MF A01 CSCL 13I

Kinematic errors in spiral bevel gears are a major source of noise and vibrations in transmissions. A method for the generation of Gleason's spiral bevel gears which provides conjugated gear tooth surfaces and an improved bearing contact was developed. A computer program for the simulation of meshing, misalignment, and bearing contact was written. Author

**N86-25823*#** Computer Software Management and Information Center, Athens, Ga.
**FOURTEENTH NASTRAN USERS' COLLOQUIUM**
May 1986 337 p refs Colloquium held in San Diego, Calif. 5-9 May 1986
(Contract NASW-3247)
(NASA-CP-2419; NAS 1.55:2419) Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

The proceedings of a colloquium are presented along with technical papers contributed during the conference. Reviewed are general applications of finite element methodology and the specific application of the NASA Structural Analysis System, NASTRAN, to a variety of static and dynamic sturctural problems.

**N86-25826*#** Aerostructures, Inc., Arlington, Va.
**DYNAMIC AND AEROELASTIC ANALYSES OF TURBOSYSTEMS IN NASTRAN**
V. ELCHURI and P. R. PAMIDI (RPK Corp., Columbia, Md.) *In* Computer Software Management and Information Center Fourteenteh NASTRAN Users' Colloquium p 56-60 May 1986 refs
Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

Several new capabilities dealing with the dynamic and aeroelastic analyses of turbosystems have been added as standard features to the April 1986 release of NASTRAN. A brief description is given of these capabilities and their implementation in NASTRAN are outlined. Author

**N86-25831*#** Naval Ship Research and Development Center, Bethesda, Md.
**EXPERIENCES WITH NASTRAN IN A MULTIDISCIPLINARY OPTIMIZATION ENVIRONMENT**
M. M. HURWITZ *In its* Computer Software Management and Information Center Fourteenth NASTRAN Users' Colloquium p 145-153 May 1986 refs
Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

NASTRAN and COPES/CONMIN were used in the early-stage design optimization of a propeller and shaft. The work was undertaken, in part, to assess the performance of these programs for such a task. While the optimization was successful, some drawbacks to the approach surfaced and are discussed. Author

**N86-25838*#** Naval Ocean Systems Center, San Diego, Calif.
**FLUTTER ANALYSIS OF LOW ASPECT RATIO WINGS**
L. A. PARNELL *In* Computer Software Management and Information Center Fourteenth NASTRAN Users' Colloquium p 247-263 May 1986 refs
Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

Several very low aspect ratio flat plate wing configurations are analyzed for their aerodynamic instability (flutter) characteristics.

All of the wings investigated are delta planforms with clipped tips, made of aluminum alloy plate and cantilevered from the supporting vehicle body. Results of both subsonic and supersonic NASTRAN aeroelastic analyses as well as those from another version of the program implementing the supersonic linearized aerodynamic theory are presented. Results are selectively compared with the experimental data; however, supersonic predictions of the Mach Box method in NASTRAN are found to be erratic and erroneous, requiring the use of a separate program. Author

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# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-36308**

**AN INTERCOMPARISON OF TURBULENCE DATA OBTAINED BY TWO AIRCRAFT DURING KONTUR**

A. GRANT (Meteorological Office, Bracknell, England) and S. ZANK (Hamburg, Universitaet, West Germany) Beitraege zur Physik der Atmosphaere (ISSN 0005-8173), vol. 59, Feb. 1986, p. 185-194. refs

To ensure that the data obtained by the two aircraft, the Falcon 20 and the Hercules C-130 which took part in the 1981 KonTur experiment, were compatible a number of side by side intercomparison runs were carried out. This paper concentrates on the results of a comparison of the turbulence data, to document the accuracy, as well as the limitations of aircraft measurements in present field studies. Agreement between velocity component power spectra is found to be within the limits of natural variability for independently measured data. Stress cospectra and covariances show good agreement. Agreement between corresponding temperature power spectra as well as between corresponding heat flux cospectra is poor. The corresponding humidity power spectra as well as flux cospectra show good qualitative agreement. Because of the lack of humidity fluxes from the intercomparisons the quantitative agreement is illustrated by humidity flux profiles. Author

**A86-36448**

**THE IMPORTANCE OF DYNAMIC STALL IN AERODYNAMIC MODELING OF THE DARRIEUS ROTOR [IMPORTANCE DU DECROCHAGE DYNAMIQUE DANS LES CALCULS AERODYNAMIQUES DU ROTOR DARRIEUS]**

P. FRAUNIE, C. BEGUIER (Aix-Marseille II, Universite, Marseille, France), and I. PARASCHIVOIU (Montreal, Universite, Montreal, Canada) Journal de Mecanique Theorique et Appliquee (ISSN 0750-7240), vol. 4, no. 6, 1985, p. 785-804. In French. refs

The CAARDEX program is defined for analyzing the behavior of Darrieus wind turbines in terms of the Reynolds number, the geometrical characteristics of the wind turbine and the spreading of the stream tubes traversing the rotor volume. It is demonstrated that the maximum power conversion efficiency of the Darrieus rotor is 0.4, with the energy capture being divided at a 4:1 ratio upstream to downstream rotor. The model shows that the velocity induced on the rotor is a function of the specific velocity and solidity, and that previous stream tube theories are valid only at low values of these parameters. CARDAAX treats the rotor disk in terms of horizontal slices of stream tubes modeled separately for the upstream and downstream segments. Account is taken of the velocity profile in the atmospheric boundary layer, which can vary significantly in the case of large wind turbines, i.e., several hundred feet high. When applied to predicting the performance of a 1 kW, 2.6 m diam prototype Darrieus wind turbine in a 10 mps flow, fair agreement is obtained for power capture/wind velocity and cyclic aerodynamic forces. Additional flow visualization data is provided to illustrate the production of turbulence in the form of vortices shed between the blades. M.S.K.

**A86-36480**

**PROBABILISTIC MODELING OF FIELDS OF ATMOSPHERIC TURBULENCE AND SEA ROUGHNESS WITH REFERENCE TO THE STUDY OF COMPLEX SYSTEMS [VEROIATNOSTNOE MODELIROVANIE POLEI TURBULENTNOSTI ATMOSFERY I MORSKOGO VOLNENIIA PRI ISSLEDOVANII SLOZHNYKH SISTEM]**

IU. I. PALAGIN, S. V. FEDOTOV, and A. S. SHALYGIN Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 31, April 1986, p. 721-727. In Russian. refs

Simulation models of atmospheric turbulence and sea roughness are developed on the basis of parametric representations of random fields. The models do not exhibit errors in relation to the spectral-correlation characteristics, require a limited computation volume, and are convenient for implementation on both digital and analog processors. The present approach is applied to the statistical modeling of the motion-control system of a flight vehicle with a radar altimeter. Author

**A86-37059*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMPARISON OF ADVANCED TURBOPROP AND CONVENTIONAL JET AND PROPELLER AIRCRAFT FLYOVER NOISE ANNOYANCE - PRELIMINARY RESULTS**

D. A. MCCURDY (NASA, Langley Research Center, Hampton, VA) ASA, Meeting, 110th, Nashville, TN, Nov. 4-8, 1985, Paper. 30 p. refs

A laboratory experiment was conducted to compare the flyover noise annoyance of proposed advanced turboprop aircraft with that of conventional turboprop and jet aircraft. The effects of fundamental frequency and tone-to-broadband noise ratio on advanced turboprop annoyance were also examined. A computer synthesis system was used to generate 18 realistic, time varying simulations of propeller aircraft takeoff noise in which the harmonic content was systematically varied to represent the factorial combinations of six fundamental frequencies ranging from 67.5 Hz to 292.5 Hz and three tone-to-broadband noise ratios of 0, 15, and 30 dB. These advanced turboprop simulations along with recordings of five conventional turboprop takeoffs and five conventional jet takeoffs were presented at D-weighted sound pressure levels of 70, 80, and 90 dB to 32 subjects in an anechoic chamber. Analyses of the subjects' annoyance judgments compare the three categories of aircraft and examine the effects of the differences in harmonic content among the advanced turboprop noises. The annoyance prediction ability of various noise measurement procedures and corrections is also examined. Author

**N86-25079#** Naval Research Lab., Washington, D. C.

**AN ASSESSMENT OF DATA QUALITY AND QUANTITY FROM AIRBORNE CLOUD PHYSICS PROJECTS FROM 1974 THROUGH 1984 Final Report, Apr. 1983 - Dec. 1984**

R. K. JECK Dec. 1985 144 p refs

(Contract DTFA03-83-A-00309)

(DOT/FAA/CT-85/37; NRL-8951) Avail: NTIS HC A07/MF A01

Airborne cloud physics projects are reviewed to assess the quantity, quality, and availability of microphysical data from clouds above the freezing level. In particular, available information is analyzed to determine whether adequate data on supercooled liquid water content (SLWC) and snow currently exist for reliably characterizing aircraft icing conditions at altitudes up to 30,000 feet over the conterminous United States (CONUS). About 1700 flights in cold clouds over CONUS are documented, and the number and value of flights having data on SLWC, snow and other hydrometeors are tabulated. B.G.

**N86-25954#** National Weather Service, Silver Spring, Md. Techniques Development Lab.
**AFOS (AUTOMATION OF FIELD OPERATIONS AND SERVICES) TERMINAL FORECAST DECODING**
D. J. VERCELLI, G. A. NORMAN, and M. M. HEFFERNAN Oct. 1985 23 p
(PB86-147360; NOAA-NWS-TDL-CP-85-2) Avail: NTIS HC A2/MF A01 CSCL 04B

Terminal forecasts (FT's) are issued by Weather Service Forecast Offices (WSFO's) for approximately 500 airports nationwide. A regularly scheduled FT is valid for the 24-h period following its issuance. The FT's are prepared manually each day at WSFO's which have FT responsibilities. Once prepared, they are then stored in the local Automation of Field Operations and Services (AFOS) database and transmitted over the AFSO communications circuits. The information in the forecasts can also be used by various applications programs at the local office (e.g., Vercelli and Norman, 1985). To do this, however, the forecasts must first be decoded. The paper describes two formula translation (FORTRAN) subroutine programs which together with their subordinate subroutines can be used to decode FT's. GRA

**N86-25956*#** Chicago Univ., Ill. Satellite and Mesometeorology Research Project.
**DFW (DALLAS-FT. WORTH) MICROBURST ON AUGUST 2, 1985**
T. T. FUJITA 1986 162 p
(Contract NGR-14-001-008; NA85AA-DR-064; NSF ATM-81-09828)
(NASA-CR-176794; NAS 1.26:176794; PB86-131638; SMRP-RP-217; LC-85-52386) Avail: NTIS HC A08/MF A01 CSCL 04B

The features of the microburst on August 2, 1985, related to the Delta 191 accident during the approach to Runway 17L of the Dallas-Ft. Worth Airport is described. Both radar and satellite data, along with ground-based measurements, were used in determining the characteristics of the parent cloud which spawned the most complicated microburst winds ever analyzed by the author. The detailed reconstruction of the airflow and the aircraft's maneuver were made possible by a series of computer analyses of the Digital Flight Data Recorder (DFDR) readout. Both measured and computed values in color diagrams that can be evaluated readily by meteorologists, pilots, structural engineers, and other interested persons in preventing microburst-related accidents in future years are presented. Author

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## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-33805**
**APPLICABILITY OF USING THE CAR-II MODEL IN DESIGN AND EVALUATION OF MULTIOPERATOR WORKSTATIONS WITH SHARED CONTROLS**
S. J. MORRISSEY, B. E. HERRING (Auburn University, AL), and M. G. GENNETTI (Stanford University, CA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1985, p. 698-701.

This study was done to show how a computerized workstation design program could be used to design and evaluate workstations having multiple operators with shared or common controls. To do this the Computerized Assessment of Reach program (CAR) was used to evaluate the cockpit of the OH-58A (Huey) helicopter. This same program was then used to demonstrate methods of cockpit redesign. Author

**A86-34923#**
**HELICOPTER FLIGHT CONTROL WITH ONE HAND**
A. L. LIPPAY, M. KING, R. V. KRUK (CAE Electronics, Ltd., Montreal, Canada), and M. MORGAN (National Aeronautical Establishment, Ottawa, Canada) (CASI, Annual General Meeting, 32nd, Montreal, Canada, May 27, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Dec. 1985, p. 335-345. refs

In a given control task, human error rate may increase in proportion to the number of control devices and mental transformations. A single device whose degrees of freedom coincide spatially with the principal task parameters, and whose dynamic characteristics provide a modicum of feedback representing the demands imposed on the system, should permit a reduction of the (human) control problem. A deflection-type side-arm controller developed in Montreal is described, which enables axis-by-axis or co-ordinated control in up to six degrees of freedom with one hand. The design minimizes unwanted inputs and cross-coupling between axes. Six-axis control was established in several spacecraft and manipulator simulations. A four-axis version has been installed in a research helicopter. Preliminary testing indicated good pilot acceptance, reduced training/familiarization requirements and - in some cases - significant improvement in control performance. A second generation engineering effort is currently in progress to produce high quality units for formal testing and eventual flight qualification. Author

**A86-35431**
**COCKPIT AUTOMATION - DESIGN AND IMPLEMENTATION ISSUES**
R. W. MOSS and J. M. REISING (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 41-45. refs
(SAE PAPER 851921)

The relationship between pilots and the electronic crew member (EC) is discussed. The use of automation for decision making and its reliability are examined; the roles of the pilot and EC in decision making are studied. The implementation of the EC is described. Three examples of EC/pilot interaction are presented. I.F.

**A86-35432**
**PILOT VEHICLE INTERFACES WITH SMART AVIONICS SYSTEMS**
L. D. POHLMANN, J. B. SHELNUTT, and J. D. GILMOUR (Boeing Military Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 47-53. refs
(SAE PAPER 851923)

Design goals for the development of smart pilot vehicle interfaces (PVIs) are examined. The basic characteristics of smart PVIs and the pilot's role in combat aircraft are described. The need for the PVIs to anticipate pilot-system communication requirements, and the pilot/PVIs interaction required for evaluating situations are studied. Methods of presenting and regulating the PVIs information for the pilots are discussed. The ability of the PVIs to discuss abstract ideas such as strategy, risk, and tactics, and the use of direct communication of the pilot's intent to the avionics systems are proposed. I.F.

**A86-36175**
**AN INTEGRATED DISPLAY FOR VERTICAL AND TRANSLATIONAL FLIGHT EIGHT FACTORS AFFECTING PILOT PERFORMANCE**
J. S. TATRO (Bell Helicopter Textron, Fort Worth, TX) and S. N. ROSCOE (New Mexico State University, Las Cruces) Human Factors (ISSN 0018-7208), vol. 28, Feb. 1986, p. 101-120. refs
(Contract N00014-81-K-0439)

As part of an overall research program to optimize both forward-looking and downward-looking tactical situation displays for all-weather instrument flight in vertical takeoff and landing (VTOL) aircraft, an integrated horizontal situation display was developed for both vertical and translational flight. This paper covers the developed and initial experimentation of the downward-looking portion of the overall display and control system. The effects of eight factors on pilot performance were tested, and a multiple regression model of VTOL pilot performance as a function of those eight factors was derived for each of three dependent performance measures. Factors having important effects were position error magnification, control order, prediction time, control gain, tracking mode, and several of their interactions. Author

**A86-36852#**
**THE USE OF ELLIPSOIDAL SOLIDS TO DISPLAY HUMAN BODY DYNAMIC RESPONSE**
D. H. LAANANEN and D. KALITA (Arizona State University, Tempe) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 2 . New York, American Society of Mechanical Engineers, 1985, p. 11-17. refs
(Contract DOT-FA03-84-P-01649)

An algorithm for displaying the human body modeled as a set of ellipsoids with hidden lines omitted is described. The algorithm is implemented as a post-processor for a dynamic simulation of an aircraft occupant and seat in a crash environment. It includes consideration of complete penetration of one ellipsoid into another and total obscuration of one by another, features which are desirable for display of the abnormal body positions that can result in a vehicle crash. Also, interaction of the ellipsoids with the polygonal representations of the restraint system and seat has been considered. Results are illustrated by examples of output produced for an aircraft crash simulation. Author

**A86-36879#**
**SIMULATION OF AIRCRAFT SEAT RESPONSE TO A CRASH ENVIRONMENT**
D. H. LAANANEN (Arizona State University, Tempe) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 241-246. refs
(Contract DOT-FA03-84-P-01649)

A three-dimensional mathematical model of an aircraft seat, occupant, and restraint system has been developed for use in analysis of light aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a finite element model of the seat structure is included. The seat model can accommodate large displacements, nonlinear material behavior, and local buckling of tubular elements. The occupant model consists of twelve segments whose dimensions and inertial properties have been determined from studies of human body anthropometry and kinematics and from measurements of anthropomorphic test dummies. The seat and occupant models are described, along with the simulation program, and some examples of output data are provided. Author

**A86-36940**
**THE ROLE OF FLIGHT SIMULATION IN HELICOPTER CREW STATION DESIGN**
J. N. DEMASI and H. P. HARPER (Sikorsky Aircraft, Stratford, CT) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1-10. refs
(SAE PAPER 851900)

The need for simulation is assessed in the context of changing missions and technology; and the helicopter simulation facilities at the Sikorsky Aircraft Division are described in detail. These facilities include the human factors engineering laboratory, the avionics laboratory, the fixed-base simulator, the motion base simulator, and an in-flight simulator. It has been shown that simulation, an essential part of the crew station design process, can be applied at many levels. Simulator capabilities must cover a broad spectrum of fidelity levels with the capability to tie real hardware with the software simulation. It is concluded that in-flight simulation is necessary to provide realism for critical mission elements and to provide a validation of anchor points. Block diagrams are included. K.K.

**N86-25113#** Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
**A REVIEW OF THE PILOT BACKACHE PROBLEM IN THE CH113 LABRADOR HELICOPTER**
A. BEACH Dec. 1985 26 p refs
(AD-A164011; DCIEM-85-R-49) Avail: NTIS HC A03/MF A01 CSCL 06S

In response to an Unsatisfactory Condition Report, complaints of back pain and discomfort induced by the pilots' seat of the CH113 Labrador helicopter were investigated. Several published reports dealing with the problem are reviewed and summarized in terms of incidence and prevalence rates, frequency, intensity, duration, location and time to pain onset. A questionnaire was developed and distributed to CH113 Labrador helicopter pilots in order to determine how closely the backache characteristics of the pilots match the characteristics reported by the general population. In addition, an evaluation of the size and shape of the Labrador seat was conducted and results were compared to published seat design guidelines and recommendations. Questionnaire results indicate that the typical backache reported by Labrador pilots is similar to the backache reported by other helicopter pilots. It is usually a dull pain in the lumbar area, most often experienced during flight and usually lasting after the mission ends. Subjective results also indicate that backache may be negatively correlated with regular exercise. Based on the symptoms identified in the questionnaire and the causes identified by other investigators, design principles for an improved seat incorporating an inflatable lumbar support and a more effective load bearing seat cushion were established. GRA

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## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-34140**
**OPTIMAL CONTROL OF DETERMINISTIC SYSTEMS VIA SHIFTED LEGENDRE POLYNOMIALS**
D.-H. SHIH and F.-C. KUNG (National Cheng Kung University, Tainan, Republic of China) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-31, May 1986, p. 451-454. refs

The synthesis of an optimal control function for deterministic systems described by integrodifferential equations is investigated. By using the elegant operational properties of shifted Legendre polynomials, a direct computational algorithm for evaluating the optimal control and trajectory of deterministic systems is developed. An example is given to illustrate the utility of this method. Author

**A86-34635**

**A COMPLETELY INTEGRATED SYSTEM FOR THE TREATMENT OF CRACK GROWTH TEST DATA**

B. J. SCHWARTZ and D. T. HUNTER (United Technologies Corp., Pratt and Whitney, Div., West Palm Beach, FL) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 606-611. USAF-supported research. refs

The process of recording, analyzing, and modeling experimental data needed for fracture mechanics calculations is typically both time consuming and expensive. This paper describes the features and operation of a computer-assisted system, that is capable of automatically performing complete engineering analysis and documentation of crack growth test data. Author

**A86-35204**

**THE DEVELOPMENT OF AN ADVANCED WEIGHT ESTIMATION TECHNIQUE FOR AIRCRAFT CONCEPTUAL DESIGN**

M. J. LOGAN (LTV Aerospace and Defense Co., Vought Aero Products Div., Dallas, TX) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 14 p. (SAWE PAPER 1645)

The development of an advanced weight estimation methodology is necessary to keep pace with ever changing aircraft technology. One such method uses state-of-the-art computer concepts to provide flexible, accurate and comprehensive weight estimation capability. Using the proposed method, structural and nonstructural weights can be computed from the actual geometry of the aircraft, the materials used, and the various design, mission, and customer requirements information. Systems and equipment weights can be accurately assessed from a data library showing actual component applications. Accuracy can be ensured through the use of only those equation which are appropriate to the aircraft type being analyzed. It is concluded that with the advent of a completely interactive, menu driven system, the weight engineer's function is significantly altered. K.K.

**A86-35326**

**1985 AMERICAN CONTROL CONFERENCE, 4TH, BOSTON, MA, JUNE 19-21, 1985, PROCEEDINGS. VOLUMES 1, 2, & 3**

Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1985. Vol. 1, 699 p.; vol. 2, 557 p.; vol. 3, 576 p. For individual items see A86-35327 to A86-35424.

Subjects investigated are concerned with robot control, adaptive control, advances in robust multivariable design techniques, model-based analysis and control, filtering and estimation, industrial control methods and applications, directions in decentralized control, plant wide process control, and robot manipulator systems. Attention is also given to robustness considerations in time domain, eigenstructure assignment, estimation, industrial applications, decentralized control, recent developments in process control, aircraft guidance and flow management, direct-drive robot arms, control applications, robust control, and linear and multivariable systems. Other topics explored are related to missile guidance and control systems, multitarget tracking and data association, control of polymerization and fermentation reactors, the emergence of artificial intelligence in process control, the application of modern control/estimation theory to aircraft control, and nonlinear systems. G.R.

**A86-35358**

**EIGENSTRUCTURE ASSIGNMENT: A TUTORIAL - I THEORY**

K. M. SOBEL (Lockheed California Co., Burbank) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 456-467. refs

A linear time invariant system and the output feedback eigenstructure problem are considered, taking into account a theorem which provides a solution to the problem. Attention is given to the problems of characterizing eigenvectors which can be assigned as closed-loop eigenvectors. Questions of feedback gain computation are explored, and aspects of constrained output feedback are discussed. A description of the application of eigenstructure assignment to flight control system design has been provided by Shapiro and Chung (1981), and by Andry et al. (1983). In this paper a review is presented of questions regarding the choice of eigenvectors for a stability augmentation system and for an autopilot for the lateral dynamics of an aircraft. The use of both output feedback and constrained output feedback is illustrated with the aid of an example. G.R.

**A86-35409*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HIGH-SPEED, AUTOMATIC CONTROLLER DESIGN CONSIDERATIONS FOR INTEGRATING ARRAY PROCESSOR, MULTI-MICROPROCESSOR, AND HOST COMPUTER SYSTEM ARCHITECTURES**

S. A. JACKLIN, J. A. LEYLAND, and W. WARMBRODT (NASA, Ames Research Center, Moffett Field, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1223-1232. refs

Modern control systems must typically perform real-time identification and control, as well as coordinate a host of other activities related to user interaction, online graphics, and file management. This paper discusses five global design considerations which are useful to integrate array processor, multimicroprocessor, and host computer system architectures into versatile, high-speed controllers. Such controllers are capable of very high control throughput, and can maintain constant interaction with the nonreal-time or user environment. As an application example, the architecture of a high-speed, closed-loop controller used to actively control helicopter vibration is briefly discussed. Although this system has been designed for use as the controller for real-time rotorcraft dynamics and control studies in a wind tunnel environment, the controller architecture can generally be applied to a wide range of automatic control applications. Author

**A86-36208**

**OPTIMIZATION IN DESIGN PROCESSES - AN INFORMATICS POINT OF VIEW**

R. F. VAN DEN DAM, J. W. BOERSTOEL, and H. A. M. DANIELS (Nationaal Luct- en Ruimtevaart Laboratorium, Amsterdam, Netherlands) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 433-450. refs

The purpose of this paper is to outline the optimization-system development at NLR. The paper starts with a discussion of the potential of mathematical optimization techniques in aeronautical engineering. Subsequently, the main requirements to be met by a general-purpose optimization system are given. Following this, the implementation at NLR is described, and some examples of applications are presented to illustrate the optimization capabilities. Author

**A86-36574**

**THE POSSIBILITY OF ACHIEVING HIGH PRODUCTIVITY WITH VECTOR-PIPELINE PROCESSORS IN SOLVING PROBLEMS OF MATHEMATICAL PHYSICS [O VOZMOZHNOSTIAKH DOSTIZHENIIA VYSOKOI PROIZVODITEL'NOSTI NA VEKTORNO-KONVEIERNYKH EVM PRI RESHENII ZADACH MATEMATICHESKOI FIZIKI]**

A. V. BABAKOV, O. S. BATSUKOV, O. M. BELOTSERKOVSKII, and L. N. STOLIAROV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 26, April 1986, p. 601-613. In Russian. refs

The paper examines aspects of the analysis of algorithms for solving problems of mathematical physics (e.g., of flow around aircraft structures) with the aim of programming these algorithms on vector-pipeline processors. The proposed method makes it possible to match the algorithm with the machine architecture, and to obtain a high-efficiency program. The proposed approach is demonstrated on a difference scheme for solving the problem of flow around a cylinder. The response-time characteristics of the program are evaluated, and it is shown that there is a five-fold increase in productivity as compared with a program obtained through translation from a high-level language. B.J.

**A86-36894#**

**THE APPLICATION OF SYSTOLIC ARRAY PROCESSOR TECHNOLOGY TO REAL-TIME CONTROL**

R. H. TRAVASSOS (Systolic Systems, Inc., San Jose, CA), K. A. FARRY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and H. C. BRIGGS (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 431-440. refs

(Contract F33615-82-C-3604; F33615-83-C-3619)

An account is given of work of the Flight Dynamics Laboratory, which is sponsoring research on the use of systolic array processor concepts for real-time control computations for aircraft and spacecraft. The motivation for the work is given and progress is documented. To date, most of the work has focused on linear multivariable control problems. Several different linear multivariable control schemes are being implemented for vibration damping in a low-frequency cantilevered beam, at sample rates up to 2000 Hz, using the PC-1000 Systolic Array Processor. Additional work has begun on a 32-processor array optimized to solve nonlinear two-point boundary value problems (such as those occurring in flight control gain optimization) in real time. D.H.

**A86-36942**

**APPLICATION OF THE OPTIMAL CONTROL MODEL TO THE DESIGN OF FLIGHT SIMULATION EXPERIMENTS**

W. H. LEVISON (BBN Laboratories, Inc., Cambridge, MA) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 19-28. refs

(SAE PAPER 851903)

The Optimal Control Model (OCM) for manually controlled systems is suggested as an aid to the design of manned flight simulation experiments. The structure of the OCM, and procedures for selecting operator-related model parameters, are reviewed. Applications of the model to the design of specific simulation experiments are summarized. Good correspondence between pre-experiment model predictions and experimental performance trends is shown, demonstrating the utility of the model in the design of simulator tasks that fall within the domain of model application. Examples presented include whole-body and tactile motion cuing, visual scene cuing, and aircraft handling qualities. Author

**A86-36943**

**TOO LITTLE TIME - TOO LITTLE MONEY**

C. A. BOHN and B. J. LEIDEN (IBM Corp., Federal Systems Div., Owego, NY) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 29-34.

(SAE PAPER 851904)

An alternative to the high cost and long time associated with typical flight simulation efforts is proposed. A facility is described whereby low fidelity simulation is used early in a development program to provide empirical data for decision making in the design process. Five DOD mission tasks were identified for implementation: (1) assault, (2) antisubmarine warfare, (3) rescue, (4) scout, and (5) command and control. The underlying laboratory characteristic is reconfigurability, which is achieved in all areas via a modular approach and everything is simplified into basic components with flexibility in how the individual components are joined for any simulation. Computer operator crew station equipment and computer generation equipment together comprise the primary parts of the lab. A brief review of the experience gained in its first six months of use is provided with a simulation sample. K.K.

**A86-36945**

**ADA FOR SIMULATORS**

M. NAROTAM (Burtek, Inc., Software Systems Group, Tulsa, OK) and C. LAYTON (Rogers State College, Claremore, OK) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 43-50. refs

(SAE PAPER 851964)

This paper presents the impact of Ada on software engineering of simulation training equipment. The advantages of Ada as the programming language for Simulators are examined. The feasibility of the use of Ada for developing simulation software and the associated cost impact are discussed. Problem areas such as real-time issues, concurrency, data identification, multi-tasking, portability and reconfigurability of software are addressed. Author

**N86-25145*#** Research Triangle Inst., Research Triangle Park, N.C. Software Research and Development.

**AN EMPIRICAL STUDY OF FLIGHT CONTROL SOFTWARE RELIABILITY Final Report**

J. R. DUNHAM and J. L. PIERCE Mar. 1986 46 p refs

(Contract NAS1-16489)

(NASA-CR-178058; NAS 1.26:178058; REPT-412U-2094-22)

Avail: NTIS HC A03/MF A01 CSCL 09B

The results of a laboratory experiment in flight control software reliability are reported. The experiment tests a small sample of implementations of a pitch axis control law for a PA28 aircraft with over 14 million pitch commands with varying levels of additive input and feedback noise. The testing which uses the method of n-version programming for error detection surfaced four software faults in one implementation of the control law. The small number of detected faults precluded the conduct of the error burst analyses. The pitch axis problem provides data for use in constructing a model in the prediction of the reliability of software in systems with feedback. The study is undertaken to find means to perform reliability evaluations of flight control software. E.A.K.

**N86-25149#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**COMPARISON OF ABSORPTION AND RADIATION BOUNDARY CONDITIONS USING A TIME-DOMAIN THREE-DIMENSIONAL FINITE DIFFERENCE ELECTROMAGNETIC COMPUTER CODE M.S. Thesis**

C. F. WILLIFORD Dec. 1985 186 p refs

(AD-A163828; AFIT/GE/ENG/85D-53) Avail: NTIS HC A09/MF A01 CSCL 20C

The Three-Dimensional Finite Difference (3DFD) computer code is compared using Absorption Boundary Conditions (ABS) versus Radiation Boundary Conditions (RBC). This comparison is made when the 3DFD code is used to study the interaction of lightning with an aircraft. The 3DFD computer code is a modified version of Rymes' 3DFD. The aircraft modeled for the paper is and F-16 Fighting Falcon. The ABC used simulates an infinite free-space by setting the conductivity of the boundary space to that of distilled water, to absorb the outgoing electromagnetic waves. The RBC simulates free-space by assigning the boundary fields to a previously calculated value. The value is calculated with a parabolic interpolation of three previous field values, which are offset in space. Therefore, the calculated value is also extrapolated to account for the time delay and position change. The results of incorporating RBC were dramatic. The ten locations sampled for the test showed marked improvement in the waveforms when using RBC's. Depending on the purpose of the analysis, this improved waveform output may be overshadowed by the 25% increase in CPU time that is needed for the more sophisticated RBC. GRA

**N86-25151#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**USING ADA IN THE REAL-TIME AVIONICS ENVIRONMENT ISSUES AND CONCLUSIONS M.S. Thesis**
D. J. WITT Dec. 1985 121 p refs
(AD-A163844; AFIT/GCS/MA/85D-6) Avail: NTIS HC A06/MF A01 CSCL 09B

This project involved studying the real-time avionics environment in which Ada will become the primary programming language in the near future. A set of issues of concern regarding the use of Ada within this environment was identified and described. Test programs, including the new Prototype Ada Compiler Evaluation Capability, were evaluated as to their applicability to these issues. The applicable test program were compiled and executed using two validated Ada compilers. Compile time and run time statistics were gathered to form a baseline against which other Ada compilers (preferably MIL-STD-1750a Ada compilers) may be compared. GRA

**N86-25168*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THEORETICAL THREE-AND FOUR-AXIS GIMBAL ROBOT WRISTS**
L. K. BARKER and J. A. HOUCK May 1986 38 p refs
(NASA-TP-2564; L-16042; NAS 1.60:2564) Avail: NTIS HC A03/MF A01 CSCL 09B

In high-performance flight simulations, a four-axis gimbal system allows all possible rotations with acceptable gimbal angle rates while it avoids the so-callled 'gimbal lock' that occurs when gimbal rotational axes are colinear. In this paper, pertinent equations (including quaternions) are assembled for a hypothetical robot wrist, functionally equivalent to this four-axis gimbal system, and also for a true three-axis gimbal robot wrist. These equations are used to simulate the rotation of a robot hand by the robot wrist in response to operator rotational velocity commands to the robot hand. Near gimbal lock (wrist singularity), excessive rotational rates occur. Scaling the rates, which is necessary for the three-gimbal robot wrist to prevent rate limiting, introduces an undesirable time delay in the robot hand rotation with respect to the commanded rotation. However, the merit of the four-gimbal robot wrist is that the fourth gimbal angle keeps the robot wrist away from the singularity so that the robot hand moves exactly as commanded. It appears that in a 'worst-type' maneuver of the robot hand, the fourth gimbal angle can be defined so that none of the gimbal angle rates exceed about twice the commanded rates. Author

**N86-25169*#** California Univ., Los Angeles.
**AN APPLICATION OF ADAPTIVE LEARNING TO MALFUNCTION RECOVERY Final Report**
R. E. CRUZ May 1986 46 p refs
(Contract NAG2-302)
(NASA-CR-166620; H-1325; NAS 1.26:166620) Avail: NTIS HC A03/MF A01 CSCL 09B

A self-organizing controller is developed for a simplified two-dimensional aircraft model. The Controller learns how to pilot the aircraft through a navigational mission without exceeding pre-established position and velocity limits. The controller pilots the aircraft by activating one of eight directional actuators at all times. By continually monitoring the aircraft's position and velocity with respect to the mission, the controller progressively modifies its decision rules to improve the aircraft's performance. When the controller has learned how to pilot the aircraft, two actuators fail permanently. Despite this malfunction, the controller regains proficiency at its original task. The experimental results reported show the controller's capabilities for self-organizing control, learning, and malfunction recovery. Author

**N86-25174#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**STUDY OF THE EFFECTS OF DISCRETIZING QUANTITATIVE FEEDBACK THEORY ANALOG CONTROL SYSTEM DESIGNS M.S. Thesis**
J. S. COUCOULES Dec. 1985 208 p refs
(AD-A164209; AFIT/GE/ENG/85D-10) Avail: NTIS HC A10/MF A01 CSCL 01C

This thesis examines the feasibility and a method of extending continuous domain Quantitative Feedback Theory (QFT) flight control system designs to the discrete domain. The results of two previous QFT analog design efforts are modified for a digital implementation. The first design effort is for the KC-135 transport aircraft. Robust analog fixed compensators are designed for three different flight conditions. The second design effort is for the AFTI/F-16 aircraft. In this design, parameter variation is due to both varying flight conditions and different aircraft configurations caused by failed surfaces. GRA

**N86-26030#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**DEVELOPMENT AND EVALUATION OF MATH LIBRARY ROUTINES FOR A 1750A AIRBORNE MICROCOMPUTER M.S. Thesis**
J. J. FRIED 4 Dec. 1985 150 p refs
(AD-A164050; AFIT/GCS/MA/85D-3) Avail: NTIS HC A07/MF A01 CSCL 09B

This project produced a run-time math library for the MIL-STD-1750A embedded computer architectures. The math library consists of the algebraic functions. In addition, the steps required for a performance analysis of the math library have been outlined. Several approximation methods were investigated. The Chebyshev Economization of Maclaurin series polynomials, and rational approximations derived from the second algorithm of Remes were determined to be the best methods available. Each function's implementation was designed to take advantage of features MIL-STD-1750A architectures. The recommended test procedures provide measures of the average and worst case generated errors within each approximation. Author (GRA)

**N86-26074#** Stevens Inst. of Tech., Hoboken, N. J. Dept. of Mechanical Engineering.
**TINE DOMAIN DESIGN OF ROBUST CONTROLLERS FOR LQG (LINEAR QUADRATIC GAUSSIAN); APPLICATION TO LARGE SPACE STRUCTURES Final Report, May 1984 - Aug. 1985**
R. K. YEDAVALLI Dec. 1985 104 p
(Contract F33615-84-K-3606)
(AD-A163635; AFWAL-TR-85-3093) Avail: NTIS HC A06/MF A01 CSCL 20K

The aspect of Robustness for linear multivariable systems in time domain is the central theme of the research under the present contract. Upper bonds on the linear, structured, time varying perturbation of an asymptotically stable linear time invariant regulator are obtained to maintain both stability and acceptable regulation, using Lyapunov approach. Improvement of the proposed measures over existing measures is illustrated with the help of examples. It is shown that by employing a scaling transformation on the nominal system, it is possible to further improve the upper bound. The proposed Perturbation Round Analysis is used to design robust controllers for Linear Quadratic Regulators with structured uncertainity. Introducing quantitative measures called Stability Robustness Index and Performance Robustness Index, design algorithms are presented by which one can achieve a trade off between nominal performance, stability robustness and performance robustness. Applications considered include aircraft control problems, large space structure control problems having uncertain modal data and mode truncation as the perturbations. GRA

**N86-26160#** Joint Publications Research Service, Arlington, Va.
**SIMULATION PROBLEM OF CONTROLLING LATERAL MOVEMENT OF AIRCRAFT DURING LANDING APPROACH Abstract Only**
N. D. BOTKIN, V. M. KEYN, and V. S. PATSKO *In its* USSR Report: Physics and Mathematics (JPRS-UPM-86-001) p 69-70 21 Jan. 1986 Transl. into ENGLISH from Prikladnaya Matematika i Mekhanika (Moscow, USSR), v. 48, no. 4, Jul. - Aug. 1984 p 560-567
Avail: NTIS HC A05

The problem of controlling lateral movement of an aircraft in the final phase of landing under windy condition is investigated. A vector differential equation is derived to describe the lateral movement of an aircraft in linear approximation. The problem is formalized as an antagonistic positional differential close-end game between two players with a convex payoff function. The controlling parameter of the first player is a scalar, so that a universal stable optimum strategy exists for the first player. The movements of the initial system of equations are modeled for the initial conditions of one of the parameters at the moment T sub o = 0. It is found that a linear control principle does not guarantee a successful landing approach under extreme perturbation, but that a combined method does provide such a guarantee. Linear control likewise does not guarantee a successful landing in the absence of extreme perturbations if initial deviations, which the combined control principle can handle, are large. Author

**N86-26161#** Joint Publications Research Service, Arlington, Va.
**PARAMETRIC OPTIMIZATION OF ALGORITHM FOR ESTIMATING VALUES OF ONE CLASS OF UNSTEADY RANDOM PROCESSES Abstract Only**
G. A. KRYZHANOVSKIY and V. I. ALESHIN *In its* USSR Report: Physics and Mathematics (JPRS-UPM-86-001) p 71 21 Jan. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk Kazakhskoy SSR: Seriya Fiziko-Matematicheskaya (Alma Ata, USSR), no. 5, Sep. - Oct. 1984 p 77-81
Avail: NTIS HC A05

Optimization of the measurement processing algorithm employed in automated air traffic control systems is investigated with respect to such observation parameters as the number of measurements processed, the digitization interval and the weighted coefficients of the algorithm. The longitudinal and lateral components of the ground speed vector are calculated by the least squares method, using a linear approximation function. The variance of the approximating function in the region of the airport is defined as the efficiency indicator in the problem of parametric optimization of the traffic control algorithm. The approach employed makes it possible to make maximum use of the capabilities of existing automated air traffic control systems and to improve ground speed determination accuracy. Author

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# PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-35146**
**WEAKLY NONLINEAR ACOUSTIC AND SHOCK-WAVE THEORY OF THE NOISE OF ADVANCED HIGH-SPEED TURBOPROPELLERS**
C. K. W. TAM (Florida State University, Tallahassee) and M. SALIKUDDIN (Lockheed-Georgia Co., Marietta) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 164, March 1986, p. 127-154. Research supported by the Lockheed-Georgia Independent Research and Development Program. refs

The problem of the acoustic field generated by a supersonic turbopropeller is formulated and solved as a boundary-value problem with the equations of motion of an inviscid compressible fluid used as the governing equations. In the blade-fixed cylindrical coordinate system used here, the disturbance field is time independent so that the solution is a function of the spatial coordinate alone; the problem is further simplified by adopting the thin-airfoil approximation. Weakly nonlinear propagation effects are incorporated into the solution following Whitham's (1974) nonlinearization procedure. Numerical results of the present theory are compared with the measurements of the Jetstar flight experiment and low-cruise Mach number open-wind-tunnel data, and good overall agreement is found. V.L.

**A86-35165#**
**MEASUREMENTS REGARDING THE EMISSION ANGLE DEPENDENCE OF PROPELLER-ACOUSTIC PRESSURE/TIME SIGNALS, TAKING INTO ACCOUNT PASSING FLIGHT CONDITIONS [VORBEIFLUGMESSUNGEN ZUR EMISSIONSWINKEL-ABHAENGIGKEIT VON PROPELLER-SCHALLDRUCK/ZEITSIGNALEN]**
M. KALLERGIS (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 20 p. In German.
(DGLR PAPER 85-112)

An understanding of the relations between operative and blade-geometrical parameters, and the resulting acoustic pressure/time signal is of particular importance for the successful development of a quiet propeller drive. This report presents experimental data which can contribute to a solution of the considered problem. Studies on the basis of measurements utilizing passing flight conditions in the free atmosphere make it possible to avoid certain difficulties which arise in wind-tunnel investigations. Measurements regarding the remote acoustic radiation field were conducted with the aid of a research aircraft and a glider. The glider was employed for the storage of acoustic signals and distance measurements. Supplementary near-field measurements were performed with another research aircraft. In this case, a microphone-array system at the wing was utilized. Details regarding the employment of gliders in the considered acoustic investigations are discussed, and a description is given of the approach employed to separate engine noise and propeller noise in near-field measurements. G.R.

**A86-35617**
**THE ROLE OF SCALE MODELS IN THE DESIGN OF 'LOW BVI NOISE' ROTORCRAFT**
K. R. SHENOY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 239-248. refs

Results from two scale model rotor acoustic tests conducted in the NASA 4mX7m wind tunnel and the United Technologies Acoustic Research Tunnel are presented to illustrate the effects of scale, blade tip shapes, thrust and flight parameters on the acoustic characteristics of helicopter rotors. The Blade-Vortex-Interaction noise is shown to be a discrete noise source which significantly affects the mid-frequency region. Further, the effect of Reynold's number at 1/20 scale is shown to be significant. The results also show that the Blade-Vortex-Interaction noise can be controlled by proper blade tip design and by undertaking proper flight procedures. Author

**A86-35618*** Cornell Univ., Ithaca, N.Y.
**A COMPARATIVE STUDY OF TAIL ROTOR NOISE MECHANISMS**
A. R. GEORGE (Cornell University, Ithaca, NY) and S.-T. CHOU IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 249-261. NASA-supported research. refs

A study was made of helicopter tail rotor noise, particularly that due to interactions with the wakes of the main rotor, hub, and fuselage, and with the engine exhaust. Both harmonic and broadband noise were analyzed. The disturbed flow into the tail rotor was modeled using combinations of aerodynamic and acoustic flow codes along with some necessary estimates of turbulence properties. Representative calculations show that the main rotor wake is the strongest contributor to both harmonic and broadband tail rotor noise. The fuselage separation wake and the engine exhaust flow are also very important to both harmonic and broadband noise. The hub and hub-shaft wakes are important contributors to the broadband noise only. The tip vortices do not seem to be important to broadband noise, but their effects on harmonic noise were not modeled accurately enough to draw any conclusions from this study. Author

**A86-35619**

**FAA/HAI HELICOPTER FLIGHT OPERATIONS NOISE TESTS AND INITIAL RESULTS**

S. A. YOSHIKAMI (FAA, Washington, DC) and C. R. COX (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 263-275. refs

This paper discusses a noise test program of eight helicopters conducted jointly by the Federal Aviation Administration and the Helicopter Association International. The program emphasized the gathering of helicopter operational noise data and information appropriate to en route and heliport land use planning. The tests are described highlighting the extensive data acquisition systems used and the varied flight operations studied. Noise levels and acoustic directivity characteristics of the eight helicopters are presented for each flight operation. Trends in the data established by these characteristics are used to identify noise abatement operational procedures. Some of the procedures are shown to be applicable to all helicopter types, while others are configuration specific. Author

**A86-35621*** General Motors Corp., Detroit, Mich.

**MODEL HELICOPTER BLADE SLAP AT LOW TIP SPEEDS - THEORETICAL AND EXPERIMENTAL CORRELATIONS**

D. C.-L. CHAN (General Motors Corp., Detroit, MI) and J. E. HUBBARD, JR. (MIT, Cambridge, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 289-295. refs

(Contract NAG2-182)

A novel data acquisition system has been designed which allows a transfer of pressure transducer and hot film data from a rotating frame to a stationary one, while collecting both loading and far field acoustic measurements simultaneously; this permits correlations to be made between experimental and theoretical predictions of blade loads and the resulting far field acoustics. The comparison of predicted acoustic pulse with experimental measurements has verified the assumptions made in the Widnall and Wolf (1980) theory for the case of low speed incompressible flow. The theory is also shown to be very sensitive to the interaction geometry and trajectory of the blade trailing vortex. O.C.

**A86-36467**

**MAXIMUM-RANGE PASSIVE FLIGHT [O PASSIVNOM POLETE NA MAKSIMAL'NUIU DAL'NOST']**

M. V. ABULADZE Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), Mar.-Apr. 1986, p. 102-105. In Russian.

The paper examines the plane-parallel motion of a rigid body with a vertical symmetry plane on a fixed vertical plane in an atmosphere of constant density and in a homogeneous gravitational field. Attention is given to the problem of determining the type of motion control near the center of mass for which the flight range at a fixed moment of time has a maximum value. A solution to the optimal problem is obtained which yields the precise upper-bound estimate of the maximum flight range for the body considered, as well as the upper-bound estimate for bodies of arbitrary shape. B.J.

**A86-36710**

**THE EFFECT OF RANDOM FORCES ON NONLINEAR OSCILLATING SYSTEMS [O VOZDEISTVII SLUCHAINYKH SIL NA NELINEINYE KOLEBATEL'NYE SISTEMY]**

IU. A. MITROPOLSKII and V. G. KOLOMIETS (AN USSR, Institut Matematiki, Kiev, Ukrainian SSR) Matematicheskaia Fizika i Nelineinaia Mekhanika (ISSN 0233-7568), no. 5, 1986, p. 23-34. In Russian. refs

The paper develops asymptotic methods which are connected with the averaging method and which can be applied in the theory of nonlinear stochastic differential equations and nonlinear random vibrations. The application to the random vibrations of aircraft is noted. B.J.

**N86-25216*#** United Technologies Research Center, East Hartford, Conn.

**HELICOPTER ROTOR NOISE DUE TO INGESTION OF ATMOSPHERIC TURBULENCE Final Report**

J. C. SIMONICH, R. K. AMIET, R. H. SCHLINKER, and E. M. GREITZER (Massachussetts Inst. of Technology, Cambridge) Washington NASA May 1986 150 p refs

(Contract NAS1-17096)

(NASA-CR-3973; NAS 1.26:3973) Avail: NTIS HC A07/MF A01 CSCL 20A

A theoretical study was conducted to develop an analytical prediction method for helicopter main rotor noise due to the ingestion of atmospheric turbulence. This study incorporates an atmospheric turbulence model, a rotor mean flow contraction model and a rapid distortion turbulence model which together determine the statistics of the non-isotropic turbulence at the rotor plane. Inputs to the combined mean inflow and turbulence models are controlled by atmospheric wind characteristics and helicopter operating conditions. A generalized acoustic source model was used to predict the far field noise generated by the non-isotropic flow incident on the rotor. Absolute levels for acoustic spectra and directivity patterns were calculated for full scale helicopters, without the use of empirical or adjustable constants. Comparisons between isotropic and non-isotropic turbulence at the rotor face demonstrated pronounced differences in acoustic spectra. Turning and contraction of the flow for hover and low speed vertical ascent cases result in a 3 dB increase in the acoustic spectrum energy and a 10 dB increase in tone levels. Compared to trailing edge noise, turbulence ingestion noise is the dominant noise mechanism below approximately 30 rotor harmonics, while above 100 harmonics, trailing edge noise levels exceed turbulence ingestion noise by 25 dB. Author

**N86-25217*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**AN ESTIMATE OF THE ENROUTE NOISE OF AN ADVANCED TURBOPROP AIRPLANE NASA-TM-87302 E-3020 NAS 1.15:87302 HC A02/MF A01**

J. H. DITTMAR Apr. 1986 24 p refs

(NASA-TM-87302; E-3020; NAS 1.15:87302) Avail: NTIS HC A02/MF A01 CSCL 20A

The enroute noise of an Advanced Turboprop powered aircraft was estimated. The measured noise levels were roughly equivalent in annoyance to the noise 15.24 m from an automobile traveling at 80 km/h. It is felt that these levels would not illicit noise complaints from urban areas during the day but might be a slight annoyance in rural areas or in urban areas at night. Although it is not felt that the enroute noise is a major problem, it is indicated that a reduction in the enroute noise could improve the acceptability of advance turboprop airplanes. Author

**N86-25218*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**AN EXPERIMENTAL INVESTIGATION OF REDUCING ADVANCED TURBOPROP CABIN NOISE BY WING SHIELDING**

J. H. DITTMAR 1986 37 p refs Presented at the 10th Aeroacoustics Conference, Seattle, Wash., 9-11 Jul. 1986; sponsored by AIAA

(NASA-TM-87112; E-2713; NAS 1.15:87112) Avail: NTIS HC A03/MF A01 CSCL 20A

An experimental investigation was undertaken to determine if wing shielding could reduce the noise impacting the fuselage of an advanced turboprop airplane. Four wings were tested behind two eight-bladed propeller models. Significant shielding of the propeller noise was observed and a particular wing-propeller geometry was identified to provide the most shielding. Specifically, an up-inboard rotation would be needed for a low-wing airplane and a down-inboard rotation for a high-wing airplane. As the axial Mach number was increased, the position where the shielding starts moved farther downstream. This shift in the start of shielding was roughly a straight line with respect to Mach number between M = 0.7 and M = 0.8. At M = 0.85 the start of shielding does not shift any farther downstream. A simple barrier noise-reduction model gave the same trends with transducer positions as did the data, and, if corrected for Mach number shift, the model might be used to provide estimates of the wing shielding. Besides providing a barrier to the noise reaching the shielded area, the wing also reflects some of the noise back onto the unshielded area. This can make the noise difference between the unshielded and shielded areas of the fuselage larger than would be expected by simple wind shielding. Author

**N86-25220*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AIRCRAFT NOISE PREDICTION PROGRAM THEORETICAL MANUAL: PROPELLER AERODYNAMICS AND NOISE**

W. E. ZORUMSKI, ed. and D. S. WEIR, ed. (PRC Kentron, Inc., Hampton, Va.) Jun. 1986 256 p refs 3 Vol.

(NASA-TM-83199-PT-3; L-15937; NAS 1.15:83199-PT-3) Avail: NTIS HC A12/MF A01 CSCL 20A

The prediction sequence used in the aircraft noise prediction program (ANOPP) is described. The elements of the sequence are called program modules. The first group of modules analyzes the propeller geometry, the aerodynamics, including both potential and boundary-layer flow, the propeller performance, and the surface loading distribution. This group of modules is based entirely on aerodynamic strip theory. The next group of modules deals with the first group. Predictions of periodic thickness and loading noise are determined with time-domain methods. Broadband noise is predicted by a semiempirical method. Near-field predictions of fuselage surface pressrues include the effects of boundary layer refraction and scattering. Far-field predictions include atmospheric and ground effects. Author

**N86-26162*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EXPERIMENTAL STUDY OF THE EFFECTS OF INSTALLATION ON SINGLEAND COUNTER-ROTATION PROPELLER NOISE**

P. J. W. BLOCK Apr. 1986 33 p refs Original contains color illustrations

(NASA-TP-2541; L-16046; NAS 1.60:2541) Avail: NTIS HC A03/MF A01 CSCL 20A

Measurements which are required to define the directivity and the level of propeller noise were studied. The noise radiation pattern for various single-rotation (SR) propeller and counter-rotation (CR) propeller installations were mapped. The measurements covered + or - 60 deg from the propeller disk plane and + or - 60 deg in the cross-stream direction. Configurations examined included SR and CR propellers at angle of attack and an SR pusher installation. The increases in noise that arise from an unsteady loading operation such as an SR pusher or a CR exceeded 15 dB in the forward axial direction. Most of the additional noise radiates in the axial directions for unsteady loading operations of both the SR pusher and the CR tractor. E.A.K.

**N86-26163*#** Cornell Univ., Ithaca, N.Y. School of Mechanical and Aerospace Engineering.

**HELICOPTER TAIL ROTOR NOISE ANALYSES Final Technical Report, 1 Jun. 1985 - 31 Jan. 1986**

A. R. GEORGE and S. T. CHOU Jan. 1986 66 p refs

(Contract NAG1-590)

(NASA-CR-176829; NAS 1.26:176829) Avail: NTIS HC A04/MF A01 CSCL 20A

A study was made of helicopter tail rotor noise, particularly that due to interactions with the main rotor tip vortices, and with the fuselage separation mean wake. The tail rotor blade-main rotor tip vortex interaction is modelled as an airfoil of infinite span cutting through a moving vortex. The vortex and the geometry information required by the analyses are obtained through a free wake geometry analysis of the main rotor. The acoustic pressure-time histories for the tail rotor blade-vortex interactions are then calculated. These acoustic results are compared to tail rotor loading and thickness noise, and are found to be significant to the overall tail rotor noise generation. Under most helicopter operating conditions, large acoustic pressure fluctuations can be generated due to a series of skewed main rotor tip vortices passing through the tail rotor disk. The noise generation depends strongly upon the helicopter operating conditions and the location of the tail rotor relative to the main rotor. Author

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-35644**

**HELICOPTER CUSTOMER SUPPORT - ARE WE AWARE OF HOW GREAT IT CAN BE**

J. J. ALEXANDER (Aerospatiale Helicopter Corp., Grand Prairie, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 617-622. refs

Helicopter manufacturers' customer support services encompass the provision of spare parts, maintenance and repair equipment, and technical expertise, to customers on the basis of analyses of product histories. The manufacturer must address the service requirements of pilots, maintenance personnel, and spare parts inventory managers, in addition to members of administrative and financial departments. Attention is presently given to support service requirement information flowing from customers to manufacturers, typical product accident/incident cause analysis, and both obvious and hidden expenditures by customers that must be anticipated by support services. O.C.

**A86-35645**

**THE FIELD REPRESENTATIVE 'FRONT LINE ACTIONEER'**

W. G. TRIPP (United Technologies Corp., Sikorsky Aircraft Div., Stratford,, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 623-627.

A helicopter manufacturer's field service representative must address the maintenance, operation and support requirements of customers operating one or several of the manufacturer's products. In addition to the technical expertise required to soundly advise operators on cost-minimizing procedures in operations, maintenance and repair, the representative must also possess and exercise evaluative judgment through which the manufacturer's staff can act on customers feedback. The degree to which a field service representative's work will enhance customer performance and satisfaction is presently assessed. O.C.

**A86-35647**
**SPARE PARTS PRICING - IMPACT ON LOGISTICS SUPPORT**
J. K. HANCOCK (Boeing Vertol Co., Ridley Park, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 635-637.

A task force composed of management-level representatives from all major organizations of a military helicopter manufacturer was formed in response to a 10-point program, promulgated in July 1983 by the Secretary of Defense, in order to reform spare parts procurement practices. A corporate spares policy was duly formulated by October 1983. Attention is given to the effects of this policy on price lists, recommended minimum quantities, combined buy practices, low intrinsic value spares, ground support equipment, spare parts data tracking, and cost avoidance. O.C.

**N86-25300#** Army Aviation Systems Command, St. Louis, Mo.
**COST ESTIMATING RELATIONSHIPS FOR FIXED WING AIRCRAFT: LIST PRICE VERSUS EMPTY WEIGHT Final Report**
W. J. DITTO Sep. 1985 15 p refs
(AD-A164196; USAAVSCOM-TM-85-F-7) Avail: NTIS HC A02/MF A01 CSCL 15E

This Cost Estimating Relationship (CER) for fixed wing aircraft was developed to estimate the unit cost of a twin engine, commercial, turboprop aircraft procured off the shelf. The Army has a limited fixed wing capability and most of this capability is procured in a commercial environment instead of through a typical rotor wing procurement cycle. The list price in the commercial market includes both engines and standard avionics, while in a typical government rotor wing procurement these items are Government Furnished Equipment. Therefore, this CER was developed using the parameter of empty weight and aircraft commercial list price. The data collected were analyzed using the Statistical Analysis System (SAS) on the AVSCOM Scientific and Engineering Computer System. The program developed is a linear regression of the form ($y = a + bx$), and the results are shown in the report. GRA

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## GENERAL

**N86-26276*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**LANGLEY AEROSPACE TEST HIGHLIGHTS, 1985**
May 1986 100 p
(NASA-TM-87703; NAS 1.15:87703) Avail: NTIS HC A05/MF A01 CSCL 05A

The role of the Langley Research Center is to perform basic and applied research necessary for the advancement of aeronautics and space flight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. Significant tests which were performed during calendar year 1985 in Langley test facilities, are highlighted. Both the broad range of the research and technology activities at the Langley Research Center and the contributions of this work toward maintaining United States leadership in aeronautics and space research, are illustrated. Other highlights of Langley research and technology for 1985 are described in Research and Technology-1985 Annual Report of the Langley Research Center. Author

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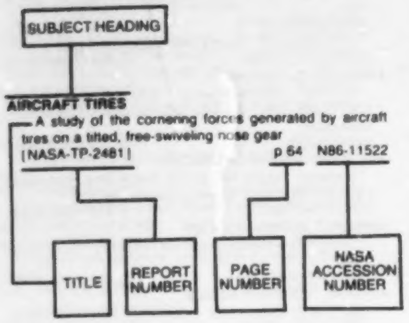
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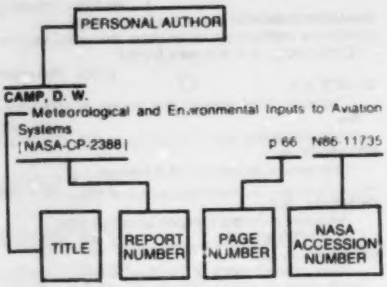

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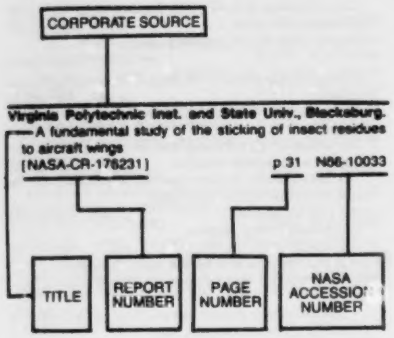
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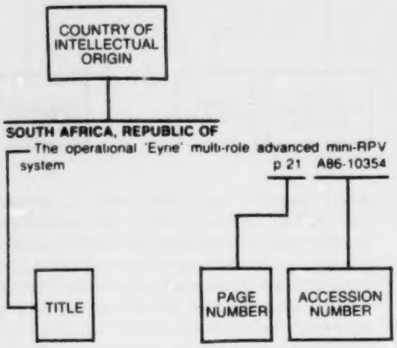
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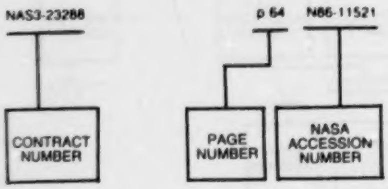

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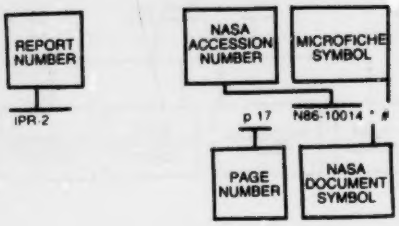

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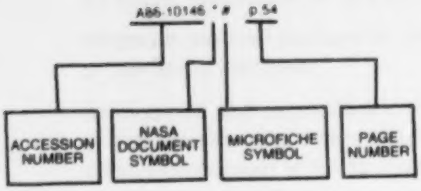

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NASA SP-7037(205)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY
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## (Supplement 205)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in September 1986 in

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 517 reports, journal articles and other documents originally announced in September 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

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Includes sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

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Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**Category 18 Space Sciences** N.A.

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# TYPICAL REPORT CITATION AND ABSTRACT

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**ACCESSION NUMBER** → **N86-10033*#** Virginia Polytechnic Inst. and State Univ., ← **CORPORATE SOURCE**
Blacksburg. Dept. of Chemistry.
**TITLE** → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
**AUTHORS** → N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs
**PUBLICATION DATE**
**CONTRACT NUMBER** → (Contract NAG1-300)
**AVAILABILITY SOURCE**
**REPORT NUMBERS** → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF ← **PRICE CODE**
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The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

# TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

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**ACCESSION NUMBER** → **A86-11041*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS** ← **TITLE**
**AUTHOR** → D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) ← **AUTHOR'S AFFILIATION**
**CONFERENCE TITLE** → AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)
**CONFERENCE DATE**

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 205)*

OCTOBER 1986

## 01

## AERONAUTICS (GENERAL)

**A86-38356**
**PILOT'S ASSOCIATE - WHAT SHOULD IT DO?**
R. L. STROM (Rockwell International Corp., Pittsburgh, PA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 5 p.
(SAE PAPER 851890)

This paper describes the analysis required to select which crew decisions and actions should be assigned to an airborne computer system, capable of handling massive amounts of data and accomplishing speeds of analysis, calculation, and decision beyond human capability. Such a system is referred to as a Pilot's Associate (PA). The required processing system would probably utilize a combination of Artificial Intelligence (AI) concepts and deterministic algorithms. To determine what functions must be accomplished by the combination of the aircraft crew and an expert system requires a top-down analysis of required functions, from which can be derived decision and action requirements, data processing requirements and allocations of performance between the PA and the crew. Author

**A86-39567#**
**NEXT GENERATION AIRCRAFT STRUCTURES - THE NEED FOR CO-ORDINATED CANADIAN R & D PROGRAMS**
J. THOMPSON (CASI, Structures and Materials Section, Ottawa, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 50-53.

The directions which Canadian R & D in aircraft structures are expected to take over the next 25 yr are discussed. Current programs are targeted at developing composite secondary structures which can be certified for regular use, particularly in the DHC-7 and DHC-8 aircraft. Near- and mid-term research will examine carbon-fiber, aramid, aramid/aluminum hybrids, aluminum lithium alloys, and powder metallurgy ingot aluminum alloys, mainly for commuter aircraft. The parts which will receive the most attention are wings and flaps, empennages, fuselages and flight control surfaces. The efforts will require the development of standardized analytical and numerical tools, NDE testing methods and test procedures, extensive material characterization studies, and funding and performance of components testing programs. It is notable that commuter aircraft primary structures will be required to be as resistant to impact damage from, e.g., birds, as typical modern larger passenger aircraft. M.S.K.

**A86-39570#**
**COST-EFFECTIVE REMOTE-SITE TESTING**
M. P. ROSEMEYER (De Havilland Aircraft of Canada, Ltd., Downsview) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 75-80.

The DASH-8 aircraft was flight-tested using short-term trials at remote sites in order to control testing costs and accelerate the test program. Additionally, data acquisition and analysis were performed using computers and instrumentation used with the DASH-7 aircraft, along with 10 new commercially-available microcomputers. The flight tests were distributed among two sites in Arizona and one in Michigan, with most test trips lasting shorter than 6 weeks, an interval regarded as optimum for a maximum sustained team effort. Cooperation was gained with the local ATC in order to coordinate the efforts with normal traffic patterns and to avoid any conflicts between required testing and ATC priorities. Short tabulations are provided of the man-hours, travel times, and test-time cost savings achieved while accomplishing the flight tests needed for certification. Finally, the success of efforts to design the DASH-8 right the first time are emphasized, since only three structural changes were identified as necessary and implemented during the development period. M.S.K.

**N86-26277*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**SUMMARY OF RESULTS OF NASA F-15 FLIGHT RESEARCH PROGRAM**
F. W. BURCHAM, JR., G. A. TRIPPENSEE, D. F. FISHER, and T. W. PUTNAM Apr. 1986 34 p refs Presented at the AIAA 3rd Flight Testing Conference, Las Vegas, Nevada, 2-4 Apr. 1986
(NASA-TM-86811; H-1341; NAS 1.15:86811; AIAA-86-9761)
Avail: NTIS HC A03/MF A01 CSCL 01B

NASA conducted a multidisciplinary flight research program on the F-15 airplane. The program began in 1976 when two preproduction airplanes were obtained from the U.S. Air Force. Major projects involved stability and control, handling qualities, propulsion, aerodynamics, propulsion controls, and integrated propulsion-flight controls. Several government agencies and aerospace contractors were involved. In excess of 330 flights were flown, and over 85 papers and reports were published. This document describes the overall program, the projects, and the key results. The F-15 was demonstrated to be an excellent flight research vehicle, producing high-quality results. Author

**N86-26278#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**AEROSPACE KNOWLEDGE MAGAZINE (SELECTED ARTICLES)**
X. LI, Z. WANG, and X. WU 15 Jan. 1986 19 p Transl. into ENGLISH from Hangkong Zhishi (China), no. 6, 1985 p 17-21
(AD-A164720; FTD-ID(RS)T-1008-85) Avail: NTIS HC A02/MF A01 CSCL 01C

This Chinese translation is of three articles from Aerospace Knowledge Magazine. The articles are Su-7 and Su-17 about the Soviet fighter bomber and the variable geometry swept-wing fighter bomber; Infrared Decoy about the scapegoat infrared countermeasure against infrared guided missiles. Smoke and flame decoys, composite decoys and fuel type decoys are also discussed in this article. The last article is entitled Distinguishing between several Soviet aircraft. GRA

**N86-26279#** Air Command and Staff Coll., Maxwell AFB, Ala.
**WHAT USAF AIRCRAFT SHOULD BE THE WILD WEASEL OF THE 1990'S?: AN ASSESSMENT OF THE F-4G, THE F-15WW, AND F-16WW M.S. Thesis**
M. J. NEITZEL 7 Jun. 1985 125 p
(AD-A164727) Avail: NTIS HC A06/MF A01 CSCL 01C

The USAF Wild Weasel mission was born in 1965 during the Vietnam conflict. The purpose of the mission was to counter the

serious radar-directed threats that were decimating the US fighter arsenal. While the current F-4G Wild Weasel aircraft has effectively met the threat into the 1980's, its capabilities reflect the aircraft's 1950's design. Meanwhile, the Soviet Union is fielding many technologically advanced radar-directed threats that bring the adequacy of the F-4G into question. This study investigated what characteristics will be required to defeat the threat of the 1990's. Next, the F-4G, F-15WW, and F-16 Wild Weasel proposal were compared against the aircraft characteristics needed (as determined by a poll of experienced officers) to survive the threats in the 1990's. This thesis concludes that the F-15WW possesses the most desirable characteristics to serve as the Wild Weasel aircraft for the 1990's.
GRA

**N86-26280#** Army Command and General Staff Coll., Fort Leavenworth, Kansas.
**THE C-17: AN ATTEMPT AT INCREASED AIRLIFT VERSATILITY M.S. Thesis**
J. W. STONE 7 Jun. 1985 127 p
(AD-A164822) Avail: NTIS HC A07/MF A01 CSCL 01C

The Airlift Master Plan was developed as a guide for achieving long-term military airlift objectives. The cornerstone of the plan is the development and acquisition of the C-17. Although the C-17's direct-delivery concept is new, the quest for expanded aircraft versatility has been continually pursued in previous airlift aircraft development programs. Thus the C-17 is not the first aircraft that has attempted to combine the traditionally separate roles of intertheater and intratheater airlift. The most recent attempt at developing an aircraft capable of meeting both strategic and tactical requirements resulted in the C-5A. The C-5A failed to achieve the operational versatility predicted by its proponents and that failure has given rise to serious questions in regard to the C-17's probability of success in realizing its expanded airlift goals. A comparison of the C-5A and C-17 programs revealed the differences in concept formulation, design and acquisition strategy which will allow the C-17 to achieve its operational goals. The study further concludes that the direct-delivery concept is a valid airlift objective and current technology permits the development of an aircraft with the performance capabilities necessary to fulfill that objective. GRA

**N86-26281#** Air Force Academy, Colo.
**AIR FORCE ACADEMY AERONAUTICS DIGEST Final Report**
J. H. RUSSELL and M. HALE Sep. 1985 85 p
(AD-A164940; USAFA-TR-85-11) Avail: NTIS HC A05/MF A01 CSCL 05I

This Digest covers unclassified research in aeronautics by individuals assigned to or associated with the United States Air Force Academy. Partial contents: Aerodynamics - Unsteady forces acting on a flat plate airfoil undergoing chord deformation, and Unsteady surface pressure measurements on a pitching airfoil; and Engineering Education - Undergraduate airbreathing propulsion at the US Air Force Academy, and How to fairly account for an excused exam.
GRA

**N86-26282#** Naval Postgraduate School, Monterey, Calif.
**AN ANALYSIS OF S-3 SDLM (STANDARD DEPOT LEVEL MAINTENANCE) CORROSION DOCUMENTATION PROCEDURES M.S. Thesis**
S. L. HANSON and M. E. KARR Dec. 1985 77 p
(AD-A165588; NPS554-85-011) Avail: NTIS HC A05/MF A01 CSCL 05A

When senior personnel in Naval aviation are asked the question, How much time and money are we spending on corrosion prevention and correction?, fairly accurate estimates can be obtained for the organizational and intermediate levels of maintenance because they break out these costs in their maintenance data reporting systems. It is virtually impossible to quantify these same costs at the depot level since their current reporting system will not allow for the collection of such information. A second problem, caused by this rather limited reporting system, concerns the inability of the depot level engineering staff to gather sufficient accurate information about the types, extent, and locations of corrosion that occur on aircraft. This report provides a system design and implementation plan for corrosion monitoring for the Naval Air Rework Facility at Alameda, California. A computerized system for corrosion data collection and processing is needed. Research in this area led to the Depot Maintenance Data System (DMDS).
GRA

**N86-26283*#** Notre Dame Univ., Ind. Dept. of Aerospace and Mechanical Engineering.
**PROCEEDINGS OF THE CONFERENCE ON LOW REYNOLDS NUMBER AIRFOIL AERODYNAMICS**
T. J. MUELLER, ed. Jun. 1985 356 p refs
(Contract NASA ORDER L-77177-B; N00014-85-G-0123)
(NASA-CR-177308; NAS 1.26:177308; AD-A163609; UNDAS-CP-77B123) Avail: NTIS HC A16/MF A01 CSCL 01B

Current interest in a variety of low Reynolds number applications has focused attention on the design and evaluation of efficient airfoil sections at chord Reynolds numbers from about 100,000 to about 1,000,000. These applications include remotely piloted vehicles (RPVs) at high altitudes, sailplanes, ultra-light man-carrying/man powered aircraft, mini-RPVs at low altitudes and wind turbines/propellers. Although the design and evaluation techniques for airfoil sections above chord Reynolds numbers of 500,000 are reasonably well developed problems related to boundary layer separation and transition have made it difficult to extend these techniques to lower Reynolds numbers. Presently available design and analysis techniques require improved criteria for laminar separation transition, reattachment and turbulent separation. Mathematical models of these complex phenomena require additional very careful experimental studies. GRA

**N86-27178#** Minority Services, Inc., Washington, D.C.
**MICROWAVE LANDING SYSTEM (MLS) STATION INTERFACE CONTROL REPORT**
Jun. 1986 182 p
(Contract DTFA01-86-Y-01010)
(DOT/FAA/PM-86/17) Avail: NTIS HC A09/MF A01

This report contains requirements which are applicable to the MLS Interfaces for the system control functions, Remote Monitoring and Maintenance System status and maintenance reporting functions, and the synchronization function. The purpose is to provide for complete interoperability of MLS ground equipments which may have a different design and/or manufacturer, serving opposite ends of the same runway. Information is provided for the communication protocol and message/data formats between the Maintenance Processor Subsystem (MPS) and the Remote Monitoring System (RMS) of an MLS. The Remote Control and Status Unit (RCSU) is the RMS focal point for the MLS. Similar information is provided for the interface/communications between the RCSU and the stations of the MLS. A Printer/Terminal (P/T) provides active interface with the MLS stations. Information on the P/T interface and the set of P/T commands is provided. The various operating/non operating states of the MLS are given. A set of data parameters is given which may be transmitted to the MPS as descriptors of the MLS operating status history, site related parameters, monitor related parameters and maintenance related parameters. Parameter information is provided for the intra-system synchronization function.
Author

**N86-27179#** Grand Canyon National Park, Ariz. Resources Management and Planning Div.
**AIRCRAFT INFORMATION PACKET (GRAND CANYON NATIONAL PARK, ARIZONA)**
Sep. 1985 53 p
(PB86-159704; GCNP/AIR/INFO-85/1) Avail: NTIS HC A04/MF A01 CSCL 01B

The Aircraft Information Packet presents an overview of the aircraft overflight issue at Grand Canyon National Park which was made available for public review in September 1985. The packet consists of a task directive and pre-planning booklet distributed for public review and comment from September 17, 1985 through December 17, 1985. The task directive provides a background of the aircraft issue at Grand Canyon, the legal and policy constraints under which the management plan is being developed, a summary

of research to date, and a discussion of the planning process being followed. The pre-planning booklet provides an overview of current aircraft use, a summary of public involvement to date, and an analysis of possible mitigation actions being considered to address this issue.
GRA

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-37192*** Ohio State Univ., Columbus.
**INVESTIGATIONS OF TRANSONIC TRAILING EDGE FLOWS**
S. L. PETRIE and D. S. EMMER (Ohio State University, Columbus, OH) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 199-210. refs
(Contract NSG-2298)

An experimental study of several of the trailing edge and wake turbulence properties for a NACA 64A010 airfoil section was completed. The experiments were conducted at the Ohio State University Aeronautical and Astronautical Research Laboratory in the 6 inch x 22 inch transonic wind tunnel facility. The data were obtained at a free stream Mach number of 0.80 and a flow Reynolds number (based on chord length) of 5 million. The principal diagnostic tool was a dual-component laser Doppler velocimeter. The experimental data included surface static pressures, chordwise and vertical mean velocities, RMS turbulence intensities, local flow angles, and a determination of turbulence kinetic energy in the wake at chordwise locations between the transonic shock wave and the trailing edge, in the near wake just downstream of the trailing edge and in the far wake. At the two angles of attack tested (0 and 2 degrees), the turbulence intensities and turbulence kinetic energy were observed to decay in the streamwise direction. In the far wake, for the non-lifting case, the turbulence intensities were nearly isotropic. For the two degree case, the horizontal component of the turbulence intensity was observed to be substantially higher than the vertical component.
Author

**A86-37196#**
**AERODYNAMIC CHARACTERISTICS OF A CIRCULATION CONTROLLED SYMMETRICAL AIRFOIL WITH DUAL JET**
K. KUWABARA, K. TSUBOI, H. OKAMOTO, Y. TOMINAGA, and M. YASUHARA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 386, 1986, p. 125-133. In Japanese, with abstract in English. refs

The effects of two blowing jets on the aerodynamic characteristics of a 20 percent thick, noncambered airfoil are described. The free stream wind tunnel velocity is 10 m/s and the Reynolds number is 1.7 x 10 to the 5th. Section lift, drag and pitching moment coefficients are given at various effective angles of attack. The position of the second slot has a strong effect on the characteristics and the highest lift to drag ratio is given at 55 deg from the first one. A two-jet system is found to be more effective in producing high lift than a one-jet system at the same jet-power coefficient.
Author

**A86-37769*** Army Aviation Systems Command, Moffett Field, Calif.
**CALCULATION OF HELICOPTER AIRFOIL CHARACTERISTICS FOR HIGH TIP-SPEED APPLICATIONS**
W. J. MCCROSKEY, J. D. BAEDER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and J. O. BRIDGEMAN (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, April 1986, p. 3-9. Previously announced in STAR as N86-18294. refs

In this paper, we have applied a new aerodynamic tool to the study of helicopter airfoil characteristics. We have shown that the computed airloads reproduce completely the experimental behavior of representative airfoils across the transonic regime. In addition, the computational details of the flow fields, the surface pressure distributions, and the viscous-layer characteristics enable us to trace the evolution of the physical changes that occur as m infinity or Re increases. Descriptions of the complicated development of shock waves, shock-induced separation supplement the information that has been obtained heretofore in wind tunnels. In validating our calculations and assessing the accuracy of the results, including extensive grid-refinement studies and comparisons with data from numerous wind tunnels, we have defined the capabilities and limitations of the code ARC2D more precisely. This important aspect of the investigations can complement wind-tunnel tests, by providing flow-field details that are difficult to measure and by extending the range of low parameters beyond the capabilities of existing wind tunnels. The code has now progressed from a purely research stage to almost a production stage, where it can be run by specialists in the helicopter industry.
GRA

**A86-37801**
**APPLIED AERODYNAMICS CONFERENCE, 4TH, SAN DIEGO, CA, JUNE 9-11, 1986, TECHNICAL PAPERS**
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 446 p. For individual items see A86-37802 to A86-37850.

Papers are presented on unsteady transonic flows past airfoils using the Euler equations, an analysis of elliptic grid generation techniques using an implicit Euler solver, wing-wing interference effects for cruciform missiles, stability of side forces on bodies at high angles of attack, and wind tunnel test of a model rotor with a free tip. Consideration is given to viscous-inviscid analysis of transonic and low Reynolds number airfoils, effect of Karman vortex shedding on airfoil stall flutter, a two-dimensional transonic aerodynamic design method, unsteady forces on counter-rotating propeller blades, and flow structure of lateral wing-tip blowing. Additional papers include a high order supersonic triplet singularity, coupling between vehicle motion and slender cone transition, wing and conical body of arbitrary cross-section combinations in supersonic flow, influence of forebody cross-sectional shape on wing vortex burst location, and improved computation of the transonic flow on high-lift devices.
I.S.

**A86-37802*#** North Carolina State Univ., Raleigh.
**UNSTEADY TRANSONIC FLOWS PAST AIRFOILS USING THE EULER EQUATIONS**
G. E. SMITH, H. A. HASSAN (North Carolina State University, Raleigh), and W. WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA ) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-9. refs
(Contract NGT-34-002-800)
(AIAA PAPER 86-1764)

An explicit finite difference solver for the Euler equations was developed and used to calculate the flow past two of the AGARD standard aeroelastic configurations, an NACA 64A010 and an NLR 7301. The algorithm employed uses a modified four step Runge-Kutta time stepping scheme, boundary conditions determined from the time-dependent theory of characteristics and an unsteady automatic grid generation procedure. In general, the calculated results are in good agreement with available experiment. Moreover, they demonstrate the importance of using the Euler equations for super-critical airfoils and in situations where the transonic small disturbance theory results in poor agreement with experiment.
Author

**A86-37803#**

**EULER CALCULATION FOR FLOW OVER A WING IN GROUND EFFECT**

J. E. DEESE and R. K. AGARWAL (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 10-15. Research sponsored by the McDonnell Douglas Independent Research and Development Center. refs

(AIAA PAPER 86-1765)

An Euler solver based on the finite-volume Runge-Kutta time-stepping scheme has been developed to predict the flow around airfoils and wings in ground effect. The technique is applied to a Clark Y-airfoil and a low-aspect-ratio wing (Clark Y-airfoil section) in subsonic flow. Results are compared with experimental data and PANAIR (panel method code) calculations. Author

**A86-37804#**

**AN ANALYSIS OF ELLIPTIC GRID GENERATION TECHNIQUES USING AN IMPLICIT EULER SOLVER**

J. S. MOUNTS, A. MARTINEZ (USAF, Armament Laboratory, Eglin AFB, FL), and J. F. THOMPSON (Mississippi State University, Mississippi State) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 16-26. refs

(AIAA PAPER 86-1766)

Several control function interpolation techniques in a general three-dimensional elliptic grid generation code and their effects on flow solutions using an implicit Euler algorithm are examined. These results will serve to guide the design of control function procedures and interpolation techniques in general grid generation codes. Three configurations and three grid types ('O', 'C', and 'H' grids) are examined. The results indicate that the selection of the control function interpolation techniques, which affects grid spacing, should be based on boundary curvature and spacing. The selection of the interpolation technique can then be made transparent to the user of general grid generation codes. Author

**A86-37805#**

**EULER SOLUTIONS FOR AIRCRAFT CONFIGURATIONS EMPLOYING UPPER SURFACE BLOWING (USB)**

E. ATTA, S. RAGAB, and L. BIRCKELBAW (Lockheed-Georgia Co., Marietta) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 27-35. refs

(AIAA PAPER 86-1767)

A method has been developed for calculating the flowfield around complex aircraft configurations using upper-surface blowing (USB). The method is based on a zonal grid generation approach coupled with an Euler flow solver algorithm. In this method the flowfield is divided into a number of non-overlapped regions, each containing a component of the aircraft such as a wing, a fuselage or a nacelle. H-type grids are generated independently in each region using a hybrid elliptic/algebraic grid generation scheme. An explicit finite volume Euler algorithm has been developed that is applicable to the multi-region H-type grids. The present method has been applied to a two-dimensional USB model and a realistic aircraft configuration consisting of a wing/fuselage with two integrated nacelles. Numerical results indicate that the computational method is effective in predicting the flowfield about USB-type configurations and complex aircraft geometries. Author

**A86-37806*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMBINED, NONLINEAR AERODYNAMIC AND STRUCTURAL METHOD FOR THE AEROELASTIC DESIGN OF A THREE-DIMENSIONAL WING IN SUPERSONIC FLOW**

J. L. PITTMAN and G. L. GILES (NASA, Langley Research Center, Hampton, VA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 35-44. refs

(AIAA PAPER 86-1769)

An iterative procedure for the static aeroelastic design of a flexible wing at supersonic speeds has been developed. The procedure combines a nonlinear, full-potential solver (NCOREL) with an equivalent plate structural analysis method. The NCOREL method yields significantly improved aerodynamic estimates compared to linear theory. The equivalent plate structural analysis method demonstrates an order of magnitude reduction in computer memory and execution time compared to finite-element methods. A highly swept wing is analyzed at high lift using this aeroelastic procedure. The results indicate that the wing deforms favorably due to aerodynamic loading and, consequently, that the inviscid drag levels do not vary at the required lift coefficient although the angle of attack varies significantly. A sensitivity analysis of the type required for optimization studies was also performed with the aeroelastic design procedure. Author

**A86-37809#**

**VORTEX-INDUCED BENDING OSCILLATION OF A SWEPT WING**

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 62-71. refs

(AIAA PAPER 86-1773)

An analysis of existing experimental results shows conclusively that the observed bending oscillations of a highly swept wing can not have been caused by the induced effects of a single leading edge vortex but are caused by the interaction between two leading edge vortices, one generated by a thick inner wing or wing-body glove and the other by the outboard, thin, variable sweep wing. This inner-outer wing vortex interaction is similar to that occurring on a double-delta planform wing. The cause of the negative aerodynamic damping from the vortex-interaction is the sensitivity to angle of attack and its time derivative of the spanwise location of a leading edge vortex. Author

**A86-37811#**

**AN INVESTIGATION OF IMPROVING HIGH ANGLE OF ATTACK PERFORMANCE AND FLAP EFFECTIVENESS OF A CONFIGURATION WITH DELTA WING BY SPANWISE BLOWING**

L. SHEN and Y. QIN (China Aerodynamic Research and Development Centre, Mianyang, People's Republic of China) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 79-85. refs

(AIAA PAPER 86-1777)

The paper presents an investigation conducted in a 1.4 by 1.4-m wind tunnel and an 0.4 by 0.4-m water tunnel, respectively, to determine the improvement of high angle-of-attack performance and flap effectiveness of a 60-deg delta wing configuration by spanwise blowing at wing and trailing edge flaps, respectively. The data obtained in the wind tunnel shows that spanwise blowing at the wing results in much more vortex-induced lift with blowing at rearward chordwise locations than near the leading edge at high angles of attack. Spanwise blowing at trailing edge flap induces a significant improvement to the flap effectiveness over the entire angle-of-attack range tested. Water tunnel flow visualization shows that the nozzle chordwise location has significant effects on the vortex pattern over the wing at high angle-of-attack. It is concluded from flow visualization that the nozzle ought not to be placed near the core of vortex, and that if the nozzle is located in such a way that the jet cannot intersect the core of vortex, vortex-dominated flow can be maintained over a larger extent over the wing. Author

**A86-37815*#** Massachusetts Inst. of Tech., Cambridge.
**EULER SOLUTIONS FOR THE FLOW AROUND A HOVERING HELICOPTER ROTOR**
T. W. ROBERTS and E. M. MURMAN (MIT, Cambridge, MA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 124-130. refs
(Contract NAG2-275)
(AIAA PAPER 86-1784)

A method for computing the flow around a hovering helicopter rotor is presented. The solution procedure is divided into two parts. The first part is a finite volume solution of the Euler equations for the near field flow around a rotor blade. The second part is a free wake approach for determining the wake geometry and induced velocities. These two parts are solved in a coupled fashion. The rolled-up vortex wake of the rotor is included in the Euler computational domain through a nonlinear perturbation technique. This eliminates the numerical diffusion of the wake vorticity due to truncation error and artificial viscosity without the need for excessive grid resolution near the vortex core. The method is used to compute both hovering rotor and wing/vortex interaction flows, and the results are compared to experiment. Author

**A86-37820#**
**ANALYTICAL OBSERVATIONS ON THE AERODYNAMICS OF A DELTA WING WITH LEADING EDGE FLAPS**
S. OH and D. TAVELLA (Stanford University, CA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 170-178. refs
(AIAA PAPER 86-1790)

The effect of a leading edge flap on the aerodynamics of a low aspect ratio delta wing was studied analytically using a simple vortex sheet model and compared with experiments. Particular attention was given to the influence of angle of attack and flap deflection angle on the lift and drag forces. Both lift and drag decrease with flap deflection, while the lift-to-drag ratio increases. A simple coordinate transformation was used to obtain a closed form expression for the lift-to-drag ratio as a function of flap deflection. Qualitative comparison with experiments is presented. Author

**A86-37821*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**PROSPECTS FOR DESTRUCTIVE SELF-INDUCED INTERACTIONS IN A VORTEX PAIR DUE TO SINUSOIDAL DISTURBANCES**
V. J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 179-188. refs
(AIAA PAPER 86-1791)

The vortex wakes of large transport aircraft can pose a hazard to smaller following aircraft in the vicinity of airports during landing and take-off operations if certain separation guidelines are not observed. In order to reduce the hazard potential, and thereby the separation distances, efforts are being made to find more rapid wake-dissipation mechanisms. In this paper numerical simulations are made of the three-dimensional time-dependent instabilities that might be initiated in a vortex pair by sinusoidal displacements of the filaments. The objective of the study was to find those displacements and phase angles that would produce the most rapid destruction of the vortices. It is concluded that, of the wave patterns tried on the one pair of wake filaments, the only instability mode that leads to destructive interactions of the vortices is the Scorer-Crow process. Author

**A86-37823#**
**A TWO-DIMENSIONAL TRANSONIC AERODYNAMIC DESIGN METHOD**
M. GILES and M. DRELA (MIT, Cambridge, MA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 197-204. refs
(Contract F49620-78-C-0084)
(AIAA PAPER 86-1793)

This paper demonstrates the capabilities of a new transonic, two-dimensional design method. The method is based upon the simultaneous solution of multiple streamtubes, coupled through the position of, and pressure at, the streamline interfaces. This allows the specification of either the airfoil shape (direct, analysis mode) or the airfoil surface pressure distribution (inverse, design mode). The nonlinear system of equations is formulated in a conservative manner which guarantees the correct treatment of shocks, and is solved by a rapid Newton solution method. Viscous effects can also be included through a coupled integral boundary layer analysis. The first set of results shows the effect of different far-field treatments, demonstrating the improvement in accuracy obtained by including the second-order doublet terms in addition to the usual first-order vortex term. They also compare the results to ones obtained by specifying straight far-field streamlines (corresponding to solid wall wind tunnel experiments) or constant far-field pressure (corresponding to free jet experiments) to show the sensitivity to the far-field distance. In the second set of results the method is used to design a transonic airfoil with $C(l) = 1.000$ at freestream Mach number = 0.70. It is shown that the off-design performance is improved by specifying a surface pressure distribution with a very weak shock. Viscous effects are also assessed. Author

**A86-37824#**
**A SPECTRAL HODOGRAPH METHOD FOR SHOCKLESS TRANSONIC TWO-DIMENSIONAL FLOW**
C. MAVRIPLIS (MIT, Cambridge, MA) and W. L. HARRIS (Connecticut, University, Storrs) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 205-213. NSERC-supported research. refs
(Contract N00014-82-K-0311)
(AIAA PAPER 86-1796)

An iterative numerical method involving a Chebyshev-Fourier pseudo-spectral method is constructed for the solution of two-dimensional shockless transonic potential flow in the hodograph plane. The problem is posed in the hodograph plane where the governing equation is a linear variable coefficient mixed (hyperbolic-elliptic) partial differential equation where complications due to singularities and boundary conditions arise. A numerical/analytical method is devised to solve the equation efficiently and accurately for the streamfunction. Interpolated pseudo-spectral solutions for a zero streamfunction are integrated analytically back to the physical plane to yield body coordinates. The method is tested on the design of a NACA 0012 airfoil as well as a NLR quasi-elliptical airfoil starting from a circular cylinder. In its present form the method is efficient but limited to simple bodies in transonic flow as well as sensitive to certain input parameters. Further work on this method is to extend it to yield a very efficient inverse design method for shockless airfoils in transonic flow. Author

**A86-37825*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PLANFORM EFFECTS FOR LOW-FINENESS RATIO MULTIBODY CONFIGURATIONS AT SUPERSONIC SPEEDS**

S. N. MCMILLIN and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 214-220. refs

(AIAA PAPER 86-1799)

An experimental and theoretical investigation of planform effects on a low-fineness ratio multibody configuration has been conducted in NASA Langley Research Center's Unitary Plan Wind Tunnel at Mach numbers 1.6, 1.8, 2.0, and 2.16. Experimental and theoretical values of lift, drag, and pitching moment were obtained on three configurations which varied in outboard panel planform only. The three variations were at 65 deg delta, a 70/66 deg cranked arrow, and a 20 deg trapezoidal planform . The purpose of the study was to determine the effect of wing planform on the supersonic aerodynamics and to evaluate the ability of two existing linearized-theory aerodynamic methods to predict these effects. Experimental data showed that the planforms produced the lift, drag-due-to-lift, and pitching-moment characteristics typically found on single-body configurations. However, the data also showed that planform has a minimal influence on zero-lift drag, which is not typical of single-body configurations. Theoretical aerodynamic analysis indicated that codes based on linearized theory adequately predicted the effect of planform on the supersonic aerodynamics. Author

**A86-37826#**

**AERODYNAMIC EFFECTS OF WINGTIP-MOUNTED PROPELLERS AND TURBINES**

L. R. MIRANDA and J. E. BRENNAN (Lockheed-California Co., Burbank) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 221-228. refs

(AIAA PAPER 86-1802)

A simple analytical model of the interaction between a wing and propellers or turbines is formulated and discussed in this paper. This model is particularly suited to study wingtip-mounted propellers or turbines. The computer program based on the present method, known as PROPWING, also allows the determination of the optimum spanload distribution for a wing in the presence of propellers. Correlation with available experimental data proves the validity of the subject methodology for preliminary design application. Numerical studies conducted with PROPWING indicate that substantial performance benefits can be achieved by properly mounting the propellers at the wingtips. These results appear to confirm a similar conclusion derived by NASA-Langley researchers from wind tunnel investigations of wingtip-mounted propellers and turbines. Author

**A86-37830#**

**COUNTERFLOW SONIC NOSEJET INTO A SUPERSONIC STREAM**

J. H. FOX (Calspan Corp., Arnold Air Force Station, IN) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 250-255. refs

(AIAA PAPER 86-1808)

The flow field resulting from a sonic nosejet issuing counter to a supersonic stream is computed using an implicit, thin-layer Navier-Stokes solver with bow-shock fitting. A hemisphere-cylinder submerged in a Mach 2.5 stream is analyzed. The nosejet has a nozzle diameter equal to 0.13 cylinder diameters. This configuration has a very large recirculating flow region adjacent to the jet. Comparisons of the computed pressure distribution on the nose with measured data are presented and show good agreement. The attachment location of the separated stream on the hemisphere nose is also well predicted. Various features of the flow are discussed. To demonstrate the method further, an additional computation is presented of a sonic jet issuing from an ogive nose into a Mach 6 stream. The features of the computed flow field again compare very well with experiment. Author

**A86-37831#**

**FLOW STRUCTURE OF LATERAL WING-TIP BLOWING**

C. S. LEE, D. TAVELLA, N. J. WOOD, and L. ROBERTS (Stanford University, CA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 256-264. refs

(AIAA PAPER 86-1810)

Flow field surveys of the near wake behind a rectangular wing with lateral blowing were made by using a five-hole probe in a low speed wind tunnel. The effect of the jet configuration on the wake structure was investigated by offsetting the jet vertically from the chord line and deflecting the jet relative to the span. The enhancement of lift by the jet blowing was found to be an inviscid characteristic. The favorable lift increments of the slanted down and offset up blowing were mainly due to larger displacement of the tip vortices resulting from a complex three dimensional interaction of the asymmetric jet in a cross flow. Secondary vortices rotating in the opposite direction to the primary vortices were observed for the cases with favorable lift augmentation. The presence of secondary vortices has a significant influence on the position of the primary vortices, which affects the lift increment along the whole span. The tip vortices are considerably diffused by weak lateral blowing. Author

**A86-37832#**

**PAN AIR ANALYSIS OF A TRANSPORT HIGH-LIFT CONFIGURATION**

E. N. TINOCO, C. N. BALL, and F. A. RICE, II (Boeing Commercial Airplane Co., Seattle, WA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 265-271. refs

(AIAA PAPER 86-1811)

PAN AIR panel method analyses of the 737-300 Flaps 1 and Flaps 15 takeoff configurations were performed in support of the aircraft's flight development phase during precertification flight test. The analyses were instrumental in helping to understand the complex flow phenomena about the aircraft and contributed to performance improvements in the final FAA certified configuration. Comparisons of computed results with inflight measurements of wing and nacelle pressure distributions, wing section lift coefficients, and aircraft L/D are presented. A description of the computational modeling is also included. Author

**A86-37833*#** Wichita State Univ., Kans.

**THE USE OF CURVED HIGHER ORDER PANELS FOR VORTEX SHEET MODELING**

M. G. NAGATI (Wichita State University, KS), J. D. IVERSEN, and J. M. VOGEL (Iowa State University of Science and Technology, Ames) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 272-280. Research supported by Wichita State University and NASA. refs

(AIAA PAPER 86-1812)

A method is presented for predicting the geometry of a vortex sheet trailing a lift generating wing in its vicinity. It differs from others in that it uses a continuous vorticity distribution rather than discrete vortex filaments. It was found that the results were in good agreement with available experimental data, after the initial cycle of what was to be a relaxation scheme, so that iterations for this end were unnecessary. While the technique is computing intensive, it becomes attractive when used in conjunction with panel methods applications for complete aircraft configurations. The panel method solution needs to be found only once for each streamwise station downstream of the wing. Corrections applied are geometric in nature and are independent of other computational aspects. Author

**A86-37834#**

### A HIGH ORDER SUPERSONIC TRIPLET SINGULARITY

F. A. WOODWARD IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 281-287. refs
(AIAA PAPER 86-1815)

Constant and linear distributions of triplet singularities are derived, and compared with the high order source and doublet singularities used in PANAIR. The new singularities are designed to provide piecewise linear continuity of singularity strength across all panel edges, and utilize a sub-paneling technique if necessary to enforce geometrical continuity. The singularities are built up by combining the influences of these basic distributions over 6 or 9 panel groups surrounding the control point, and effectively minimize the number of equations required to satisfy the boundary conditions of tangential flow on the external surface of the body. Author

**A86-37837*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### SUPERSONIC AIRFOIL OPTIMIZATION

J. L. PITTMAN (NASA, Langley Research Center, Hampton, VA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 302-309, 45. refs
(AIAA PAPER 86-1818)

A procedure for the optimization of supersonic airfoils is presented. A nonlinear, full-potential solver (NCOREL) is coupled with a numerical optimizer (CONMIN). The NCOREL code is a three-dimensional supersonic marching method, however, only two-dimensional (conical) results are used for the airfoil problem. Each airfoil evaluated in the NCOREL aerodynamic code is composed of a linear combination of user-specified basis airfoils. The weighting factors of the basis airfoils plus the angle of attack form the design variable vector. The inviscid drag coefficient is minimized subject to lift and crossflow Mach number gradient constraints. The optimization strategy is found to be extremely important for the efficient determination of an optimum airfoil. Author

**A86-37838#**

### THREE-DIMENSIONAL INTERACTION OF WAKES AND BOUNDARY LAYERS

L. C. SQUIRE (Cambridge University, England) and A. H. KH. MOGHADAM IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 310-319. refs
(AIAA PAPER 86-1820)

This work concerns a fundamental study of the three-dimensional aspects of the wake/boundary layer interaction as it occurs on high-lift wings, particularly the slat-wake/wing boundary layer interaction. A digital system for measuring and recording all the components of the mean velocity and the Reynolds stress tensor using a triple hot-wire probe has been developed. This system has been tested and has been used to measure the interaction between the wakes of swept aerofoils and the fully turbulent boundary layer developing on a flat plate. An important result is that the three-dimensional aspects of this flow decay quickly downstream of the aerofoil. Two cases of three-dimensional interaction have been simulated. In one case the interaction is fully three-dimensional, while in the other case the interaction can be assumed to be quasi-three-dimensional. For the quasi-three-dimensional confluent flow, the measured results have been compared with the predictions of the two-dimensional form of K-epsilon and algebraic stress turbulence models. The overall agreement between the measured and predicted results is good. However, for the turbulence flow field the agreement is less satisfactory in the initial mixing region where the three-dimensionality is strong, and it is also poor in the wall boundary layer. Author

**A86-37840*#** California Univ., Davis.

### DRAG-REDUCTION CHARACTERISTICS OF AFT-SWEPT WING TIPS

C. P. VAN DAM (California, University, Davis) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 327-338. refs
(Contract NAS1-17797)
(AIAA PAPER 86-1824)

Results are presented of a study conducted to analyze the potential aerodynamic improvements which can be obtained with aft-swept wing tips at subsonic speeds. A review and summary of previous swept-tip applications and studies are given. Additionally, the through evolution optimized tail-fin shapes of fast-cruising aquatic animals are examined as well as the wing planform shapes of sea birds. These superior long-distance travellers both display lifting-surface planform shapes with increased leading-edge sweep towards the tip. These observations and analytical results obtained with a nonlinear surface-panel method demonstrate that substantial induced-drag improvements can be obtained through the adoption of planform shapes with highly-tapered aft-swept tips. Author

**A86-37841#**

### WING AND CONICAL BODY OF ARBITRARY CROSS-SECTION COMBINATIONS IN SUPERSONIC FLOW

D. MATEESCU (McGill University, Montreal, Canada) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 339-347. refs
(AIAA PAPER 86-1826)

This paper presents an analysis of wing and conical body of arbitrary cross-section combinations in supersonic flow. Particular emphasis is given to the delta wing and elliptic cone combinations, for which analytical solutions are obtained for the spanwise variation of the lifting load coefficient; both cases of subsonic and supersonic leading edges are equally treated. In this formulation the wind incidence is allowed to change along the span, as in the case of wingbody systems with leading edge flaps, or with a continuously variable wing incidence. The theoreticcal solutions obtained for the delta wing and elliptic cone systems are in good agreement with Jorgensen's experimental results for various Mach numbers, wing spans and cross-sectional semi-axis ratios. Good agreement with the experimental results is also observed in the limit case of isolated elliptic cones. Author

**A86-37842#**

### THE EXTERNAL DRAG OF A SIMPLE AXISYMMETRIC BODY OF REVOLUTION IN SUBSONIC AND SUPERSONIC FLOW WITH VARIABLE MASS FLOWTHROUGH RATIOS

T. OSAWA (UBE Industries, Ltd., Tokyo, Japan) and H. HEWITT (Tennessee Technological University, Cookeville) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 348-354. refs
(AIAA PAPER 86-1828)

The external wave drag of a simple axisymmetric body of revolution was obtained by numerically solving the time-dependent Euler equations. The numerical algorithm used was MacCormack's explicit scheme for Mach numbers from 0.8 to 4.0. The four cases studied included a closed body, and open body with and without sting supports, and an open body with flow spillage at the intake of the flow-through duct. In order to simulate the flow spillage, a boundary was set at the inlet of the duct. The boundary condition was obtained by the one-dimensional normal shock assumption which was developed by Wyatt to given an additive drag. As a result, the present method gave good agreement with a perturbation solution for the closed body. For the open body without flow spillage, the wave drag coefficients were found to be larger than for the closed body. The boundary condition at the inlet of the flow-through duct successfully simulated the flowfield near the intake for the case of the open body with spillage. This case was also compared with experimental data, assuming the friction drag was constant, and gave good agreement. Author

**A86-37846*#** Kansas Univ., Lawrence.

**CALCULATION OF ASYMMETRIC VORTEX SEPARATION ON SLENDER DELTA WINGS WITH A VORTEX-SHEET MODEL**

C. E. LAN (Kansas, University, Lawrence) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 391-400. refs
(Contract NSG-1629)
(AIAA PAPER 86-1836)

An inviscid vortex-sheet model based on the slender wing theory is developed to examine asymmetric vortex separation at zero sideslip on delta wings. It is found that multiple asymmetric vortex configurations exist at a given angle of attack. Available data on rolling moment measurements and flow visualization are used for correlation to prove the concept. Author

**A86-37847*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AN IMPLICIT FLUX-DIFFERENCE SPLITTING SCHEME FOR THREE-DIMENSIONAL, INCOMPRESSIBLE NAVIER-STOKES SOLUTIONS TO LEADING EDGE VORTEX FLOWS**

P.-M. HARTWICH (NASA, Langley Research Center, Hampton, VA) and C.-H. HSU (Kansas, University, Lawrence) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 401-410. refs
(Contract NAG1-455)
(AIAA PAPER 86-1839)

A new, implicit finite-difference scheme designed to solve the conservative, flux-difference split Navier-Stokes equations is used to compute incompressible vortex flows around delta wings. The completely vectorizable hybrid algorithm is constructed in delta form for steady state solutions independent of the time-step sizes. The scheme combines approximate factorization in crossflow planes with a symmetric planar Gauss-Seidel relaxation in the remaining spatial direction. The governing equations are solved in curvilinear, body-fitted coordinates for treating complex geometries. The computed flow field results are compared with other theoretical and experimental data. Author

**A86-37848*#** Massachusetts Inst. of Tech., Cambridge.

**A COMPARISON OF EXPERIMENTAL AND NUMERICAL RESULTS FOR DELTA WINGS WITH VORTEX FLAPS**

K. G. POWELL, E. M. MURMAN (MIT, Cambridge, MA), R. M. WOOD, and D. S. MILLER (NASA, Langley Research Center, Hampton, VA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 411-424. refs
(Contract NAG1-358)
(AIAA PAPER 86-1840)

Computational and experimental results are presented for delta wings with vortex flaps. The wings have an undeflected leading-edge sweep of 75 deg. Flap angles of 5 deg and 10 deg, measured in the streamwise direction, are considered. The nominal angle of attack alpha is varied from 4 deg to 12 deg. Results for freestream Mach numbers of 1.7 and 2.4 are shown. Surface pressure, tuft patterns and vapor screens are given for the experimental data. Surface pressure, tuft patterns, cross-flow velocities, total pressure loss and cross-flow Mach number are given for the numerical data. C(l)-vs-alpha curves are shown for experimental and computational results. The flows are shown to be very sensitive to angle of attack, and the agreement between experimental and theoretical results is improved if the calculations are made at angles of attack slightly larger than the experimental angles of attack. The computational model correctly predicts the topology of the flow in each of the cases considered. The lift is predicted well at the higher angles of attack, but slightly overpredicted at the lower angles of attack. Author

**A86-37901**

**SPREADING OF TWO-STREAM SUPERSONIC TURBULENT MIXING LAYERS**

N. CHINZEI, G. MASUYA, T. KOMURO, A. MURAKAMI, and K. KUDOU (National Aerospace Laboratory, Kakuda, Japan) Physics of Fluids (ISSN 0031-9171), vol. 29, May 1986, p. 1345-1347. refs

Two-stream supersonic turbulent mixing layers with a free-stream Mach number of 2.3 on the high-velocity side are experimentally investigated. A large-scale vortical structure, which has been believed to dominate the development of incompressible mixing layers, is also observed in the present supersonic layers. The spreading rate of the layer is correlated with a velocity ratio of the free streams and a Mach number based on the velocity difference across the layer. Author

**A86-38258*** Aerometrics, Inc., Mountain View, Calif.

**APPLICATION OF OPTICAL INTERFEROMETRY IN COMPRESSIBLE FLOWS**

W. D. BACHALO (Aerometrics, Inc., Mountain View, CA) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 277-287. NASA-supported research. refs

Interferometry methods were applied to the investigation of steady and unsteady flows in large scale transonic wind tunnels. Holographic interferometry was demonstrated to provide reliable flow visualization and quantitative results for a number of two-dimensional flows. These conclusions were based on extensive comparisons with results obtained by other means. Data obtained on a NACA 64A010 airfoil with an oscillating flap installed in the Ames 11-foot transonic tunnel are presented. Interferograms were recorded at a free stream Mach number of 0.8, flap frequency of 30 Hertz and chord Reynolds numbers of 6.6 x 10 to the 6th and 12.3 x 10 to the 6th. The interferometric results were reduced to dynamic surface pressures, Mach contours and wake flow profiles. A new interferometry method that is capable of providing real-time interferometry data is also discussed. Author

**A86-38305*** Vigyan Research Associates, Inc., Hampton, Va.

**SWEPT WING-TIP SHAPES FOR LOW-SPEED AIRPLANES**

C. P. VAN DAM (Vigyan Research Asociates, Inc., Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p. refs
(Contract NAS1-17797)
(SAE PAPER 851770)

Preliminary results are presented of a study conducted to analyze the effects of several plan-form modifications on the aerodynamic characteristics of a high-aspect-ratio, natural laminar flow (NLW) wing. The study addresses the potential aerodynamic improvements available at both cruise and high angles of attack by use os swept wing-tip shapes. The swept wing tip appears to offer a viable addition to the lift of wing-tip designs which provide improvements in aerodynamic efficiency, with the added safety benefit of providing high angle-of-attack departure resistance. Author

**A86-38306**

**THE X-29 - A UNIQUE AND INNOVATIVE AERODYNAMIC CONCEPT**

D. FREI and M. MOORE (Grumman Corp., Bethpage, NY) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA. Oct. 14-17, 1985. 12 p. DARPA-supported research. refs
(SAE PAPER 851771)

The X-29 was conceived to demonstrate in-flight the potential advantages of several advanced and innovative technologies integrated into one vehicle design. These advanced technologies include: (1) a forward-swept wing employing a thin supercritical airfoil; (2) aeroelastically-tailored composite wing covers to control divergence; (3) a close-coupled, variable-incidence canard; (4) variable wing camber; and (5) three-surface trim configuration. An aerodynamic overview of the configuration development and integration of these technologies is presented. Wind tunnel results

and flight test results, where available, are also presented to substantiate the advantages of these innovative concepts.
Author

**A86-38313**

### COMPUTATIONAL AERODYNAMIC DESIGN - X-29, THE GULFSTREAM SERIES AND A TACTICAL FIGHTER

C. W. BOPPE (Grumman Corp., Bethpage, NY) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 47 p. refs
(SAE PAPER 851789)

Elements of computational aerodynamic design are described by tracing the development of three different aircraft configuration types. The Gulfstream series (G-II, G-III, and G-IV) illustrates from 1966 to the present the evolution of both computational tools and design philosophy. This transport experience is augmented by two distinct fighter designs that feature transonic maneuver requirements: the X-29 Forward Swept Wing Demonstrator Aircraft and a generic tactical fighter configuration. These state-of-the-art applications show how courses are charted to circumvent limitations in computerized flow simulation techniques. Problems associated with drag prediction, complex geometry modeling, nonpotential phenomena, and code convergence for extreme conditions/shapes are addressed. Primary topics in wing design are complemented with auxiliary studies performed on canards, tails, nacelles, and winglets to provide perspective for the total aircraft development process. Good and bad experiences are included. Computational Fluid Dynamics (CFD) impact is evaluated by means of performance levels achieved (wind tunnel and flight test data), resources saved, and insight provided for unscrambling complex aircraft synthesis problems. Future CFD requirements are discussed. Author

**A86-38314**

### REDUCED NAVIER-STOKES (RNS RELAXATION PROCEDURE FOR INTERNAL FLOWS WITH INTERACTION)

D. R. REDDY, R. A. DELANEY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and S. G. RUBIN (Cincinnati, University, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p. refs
(SAE PAPER 851790)

A multisweep relaxation procedure is considered in the following study for two-dimensional and three-dimensional internal flows with interaction using reduced (pressure-elliptic) Navier-Stokes (RNS) equations. The velocities and pressures are fully coupled in the algorithm, and the pressure gradient in the streamwise momentum equation is appropriately treated to simulate the elliptic interaction. A Poisson type of equation is not required. The continuity equation is directly satisfied everywhere in the flow domain. Incompressible flow solutions are obtained for a two-dimensional channel with a backward facing step and a three-dimensional duct with square cross section. The solution for these test cases demonstrates the capability of the RNS algorithm to solve internal flows with strong interaction encountered in turbomachinery passages. Author

**A86-38315**

### OPTIMIZATION OF A SUPERSONIC WING BY COMBINING LINEAR AND EULER METHODS

J. M. ROSS, J. S. REASER, and E. E. BOUCHARD (Lockheed-California Co., Burbank) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p. refs
(SAE PAPER 851791)

A combination of linear and nonlinear methods was found to be effective in designing a supersonic fighter wing. The design Mach number was 1.6, with cruise and maneuver lift coefficients of 0.1 and 0.4. The planform was a tapered arrow wing with a subsonic leading edge. It was chosen based on general aerodynamic principles tempered with practical considerations. Initial camber and twist distributions were determined from a linear method. An Euler code was then used to improve upon the linear design; chordwise loading was made more uniform, and spanwise loading was adjusted toward the ideal elliptic distribution. The nonlinear calculations suggest the best approach is to use the linear method optimization at half the desired lift coefficient, and then to modify the design based on nonlinear analysis. Author

**A86-38316**

### ENGINEERING APPLICATIONS OF AN ADVANCED LOW-ORDER PANEL METHOD

C. E. JOHNSTON, H. H. YOUNGREN, and J. S. SIKORA (Lockheed-California Co., Burbank) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 10 p. refs
(SAE PAPER 851793)

Panel methods have become important aerodynamic prediction tools for aircraft design and analysis. To demonstrate the utility and accuracy of panel methods, three applications illustrating their usage are discussed in this paper. The computer code used is Lockheed's advanced low-order QUADrilateral element PANel method (QUADPAN). The first case presents correlation of force and moment predictions on a Lockheed P-3 Orion aircraft with rotodome for airborne early warning and control (AEW and C). The ability to predict incremental effects due to the rotodome is demonstrated. The second application investigates the local flow behavior in the vicinity of the engine pylon and nacelle for a re-engined Boeing 727 derivative aircraft. Results include surface pressure distributions and the local flow characteristics using the flow-survey capability of QUADPAN. Finally, the third compares stability and rate derivative calculations for the Rockwell Space Shuttle atmospheric re-entry vehicle to wind tunnel and flight test data. Author

**A86-38326**

### APPLICATION OF THE VORTEX-LATTICE METHOD TO HIGH-ANGLE-OF-ATTACK SUBSONIC AERODYNAMICS

D. T. MOOK and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg,) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 18 p. refs
(Contract N00014-85-K-0011; AF-AFOSR-85-0158; NR PROJECT 061-201)
(SAE PAPER 851817)

The vortex-lattice method for general, unsteady, incompressible aerodynamics is described. This method can treat multiple lifting surfaces operating in close proximity, fully accounting for interference. It is not limited by planform, camber, twist, or maneuver as long as separation occurs only along known lines and vortex bursting does not occur near one of the lifting surfaces. Steady flows can be treated efficiently as special cases of uniform motion. Several examples are presented as a partial illustration of the range of problems that can be treated. These include steady and unsteady flows over rectangular and delta wings, a numerical simulation of the wing rock phenomenon, and steady and unsteady interference among two canards and a wing. In the numerical simulation of wing rock, the equation governing the motion of a delta wing mounted on a free-to-roll sting is integrated numerically by a predictor-corrector method with the aerodynamic roll moment being supplied by the vortex-lattice method. This numerical solution determines the motion of the wing and the flow-field simultaneously, fully accounting for the aerodynamic/dynamic interaction. The numerical solutions are in good agreement with available experimental data. Author

**A86-38327*** North Carolina State Univ., Raleigh.

### A THREE-DIMENSIONAL BOUNDARY-LAYER METHOD FOR FLOW OVER DELTA WINGS WITH LEADING-EDGE SEPARATION

S. H. WOODSON and F. R. DEJARNETTE (North Carolina State University, Raleigh) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 13 p. refs
(Contract NCC1-22; NCC1-46)
(SAE PAPER 851818)

A three-dimensional, laminar boundary-layer method is applied to the incompressible flow over a slender delta wing at incidence. The predictor-corrector finite-difference scheme of Matsuno is used to difference the governing equations. The method has the advantages that no iterations are required to advance the solution and the cross-flow derivatives are formed independent of the cross-field direction. The difference scheme is demonstrated to yield accurate numerical results when compared to the exact solution of the three-dimensional boundary-layer equations for parabolic flow over a moving flat plate. The method is applied to delta wings of various sweep angles at angles of attack up to 20 deg., with the inviscid solution determined using a higher-order, three-dimensional panel method. Author

**A86-38328**

**INVISCID AND VISCOUS SIMULATIONS OF HIGH ANGLE OF ATTACK FLOWS**

D. K. OTA, S. R. CHAKRAVARTHY, and J. J. GORSKI (Rockwell International Science Center, Thousand Oaks, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 15 p. refs
(SAE PAPER 851820)

High angle of attack flow for a NACA0012 airfoil has been computed using an Euler code and a Navier-Stokes code. These codes are based on an implicit finite-volume Total-Variation-Diminishing (TVD) formulation of the convection terms. Comparison of the two solutions shows that the Euler code does not result in a realistic separated flow solution while the Navier-Stokes code does. Author

**A86-38347*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A FASTER 'TRANSITION' TO LAMINAR FLOW**

P. J. BOBBLTT, E. G. WAGGONER, W. D. HARVEY, and J. R. DAGENHART (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 28 p. refs
(SAE PAPER 851855)

A discussion is given of the ongoing research related to laminar flow airfoils, nacelles, and wings where the laminar flow is maintained by a favorable pressure gradient, surface suction or a combination of the two. Design methologies for natural laminar flow airfoil sections and wings for both low and high speed applications are outlined. Tests of a 7-foot chord, 23-deg sweep laminar flow-control airfoil at high subsonic Mach numbers are described, along with the associated stability theory used to design the suction system. The state-of-the-art of stability theory is simply stated and a typical calculation illustrated. In addition, recent computer simulations of transition using the time dependent Navier-Stokes equations are briefly described. Advances in wind tunnel capabilities and instrumentation will be reviewed, followed by the presentation of a few results from both wind tunnels and flight. Finally, some suggestions for future work will complete the paper. Author

**A86-38412*#** Washington Univ., Seattle.

**EXPERIMENTS ON SUPERSONIC TURBULENT FLOW DEVELOPMENT IN A SQUARE DUCT**

F. B. GESSNER (Washington, University, Seattle), S. D. FERGUSON (Boeing Aerospace Co., Seattle, WA), and C. H. LO (Spectra Technology, Inc., Flow Technology Div., Bellevue, WA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 10 p. refs
(Contract NGR-48-002-141)
(AIAA PAPER 86-1038)

The nature of supersonic, turbulent, adiabatic-wall flow in a square duct is investigated experimentally over a development length of x/D between 0 and 20 for a uniform flow, Mach 3.9 condition at the duct inlet. Initial discussion centers on the duct configuration itself, which was designed specifically to minimize wave effects and nozzle-induced distortion in the flow. Total pressure contours and local skin friction coefficient distributions are presented which show that the flow develops in a manner similar to that observed for the incompressible case. In particular, undulations exist in total pressure contours within the cross plane and in transverse skin friction coefficient distributions, which are indicative of the presence of a well-defined secondary flow superimposed upon the primary flow. The results are analyzed to show that local law-of-the-wall behavior extends well into the corner region, which implies that wall functions conventionally applied in two-equation type turbulence models, when suitably defined for compressible flow, may also be applied to supersonic streamwise corner flows. Author

**A86-38420*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**NAVIER-STOKES COMPUTATIONS OF LEE-SIDE FLOWS OVER DELTA WINGS**

J. L. THOMAS and R. W. NEWSOME (NASA, Langley Research Center, Hampton, VA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 16 p. refs
(AIAA PAPER 86-1049)

Solutions to the Navier-Stokes equations for the flow over delta wings are computed with emphasis on the separated vortical flows developing on the lee side at high angles of attack. A recently developed implicit algorithm is used which employs upwind differencing for the pressure and convection terms and central differencing for the shear stress and heat transfer terms. Solutions to both the three-dimensional equations and the approximate conical flow equations are compared parametrically with an extensive experimental data base at supersonic speeds. The computations indicate that the conical flow approximation provides results in close agreement with the three-dimensional equations, even to angles of attack as high as 20 degrees. Good agreement with experimentally measured pressures and vapor screen photographs is obtained for the conditions investigated. The method predicts the classical pattern of vortical flow over a delta wing and transition to other flow patterns as the leading edge sweep angle and leading edge normal Mach number are varied. C.D.

**A86-38433*#** Notre Dame Univ., Ind.

**EXPERIMENTAL DETERMINATION OF THE LAMINAR SEPARATION BUBBLE CHARACTERISTICS ON AN AIRFOIL AT LOW REYNOLDS NUMBERS**

M. M. OMEARA and T. J. MUELLER (Notre Dame, University, IN) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 13 p. Research supported by the University of Notre Dame. refs
(Contract NSG-1419)
(AIAA PAPER 86-1065)

An experimental investigation was conducted in order to document the structure and behavior of laminar separation bubbles at low Reynolds numbers. Data of this type is necessary if the currently insufficient analytical and numerical models are to be improved. The laminar separation bubble which forms on a NACA 66(3)-018 airfoil model was surveyed at chord Reynolds numbers ranging from 50,000 to 200,000 at angles of attack from 8 to 12 degrees. The effects of the various testing conditions on the separation bubble were isolated, and the data was analyzed in relation to existing separation bubble correlations in order to test their low Reynolds number applicability. This analysis indicated that the chord Reynolds number and the disturbance environment strongly influence the experimental pressure distributions. These effects must be included in any analytic prediction technique applied to the low Reynolds number flight regime. Author

**A86-38436#**

**EXPERIMENTAL STUDY OF A TURBULENT HORSESHOE VORTEX USING A THREE-COMPONENT LASER VELOCIMETER**

R. ABID and R. SCHMITT (ONERA, Chatillon-sous-Bagneux, France) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 9 p. refs
(AIAA PAPER 86-1069)

The turbulent horseshoe vortex flow generated by a simplified wing-body junction has been experimentally studied. Oil surface flow visualization, static wall pressure measurements, and flow field measurements were made in the separated region upstream of the obstruction leading edge. Mean flow measurements on the plane of symmetry indicate that the three-dimensional separation was confined to a region near the plate. The region of reversed flow was approximately a fifth of the boundary layer thickness. The theoretical streamline pattern suggested by oil surface flow visualization is confirmed. C.D.

**A86-38437*#** Imperial Coll. of Science and Technology, London (England).

**THE INTERACTION BETWEEN A STRONG LONGITUDINAL VORTEX AND A TURBULENT BOUNDARY LAYER**

A. D. CUTLER and P. BRADSHAW (Imperial College of Science and Technology, London, England) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 12 p. refs
(Contract NASW-581)
(AIAA PAPER 86-1071)

This paper presents the preliminary results of a long-term investigation of the interaction of strong longitudinal vortices with turbulent boundary layers. A pair of trailing vortices is generated by a delta wing, which is mounted ahead of a flat plate so that the trailing vortices merge with the boundary layer on the upper surface of the flat plate, while the non-rolled-up part of the delta-wing wake passes below the plate. This approximates an aircraft wing with a close-coupled canard. The measurements show how the boundary-layer fluid is first subjected to large cross flow and is then transported away from the plate to circulate around the vortex core. Author

**A86-38439*#** Old Dominion Univ., Norfolk, Va.

**INFLUENCE OF NUMERICAL DISSIPATION IN COMPUTING SUPERSONIC VORTEX-DOMINATED FLOWS**

O. A. KANDIL and A. CHUANG (Old Dominion University, Norfolk, VA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 15 p. refs
(Contract NAG1-648; NAG1-591)
(AIAA PAPER 86-1073)

Steady supersonic vortex-dominated flows are solved using the unsteady Euler equations for conical and three-dimensional flows around sharp- and round-edged delta wings. The computational method is a finite-volume scheme which uses a four-stage Runge-Kutta time stepping with explicit second- and fourth-order dissipation terms. The grid is generated by a modified Joukowski transformation. The steady flow solution is obtained through time-stepping with initial conditions corresponding to the freestream conditions, and the bow shock is captured as a part of the solution. The scheme is applied to flat-plate and elliptic-section wings with a leading edge sweep of 70 deg at an angle of attack of 10 deg and a freestream Mach number of 2.0. Three grid sizes of 29 x 39, 65 x 65 and 100 x 100 have been used. The results for sharp-edged wings show that they are consistent with all grid sizes and variation of the artificial viscosity coefficients. The results for round-edged wings show that separated and attached flow solutions can be obtained by varying the artificial viscosity coefficients. They also show that the solutions are independent of the way time stepping is done. Local time-stepping and global minimum time-steeping produce same solutions. Author

**A86-38443#**

**BLOCK-STRUCTURED SOLUTION OF EULER EQUATIONS FOR TRANSONIC FLOWS**

A. ECER, J. T. SPYROPOULOS, and V. RUBEK (Indiana University; Purdue University, Indianapolis) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 10 p. refs
(Contract F49620-83-K-0034)
(AIAA PAPER 86-1080)

A block-structured solution scheme is developed for the solution of Euler equations for steady, three-dimensional, transonic flows. The Euler equations are expressed in terms of Clebsch variables. The resulting set of equations for conservation of mass, entropy (S) and the Clebsch variable eta are solved using a block-based relaxation scheme. The flow field is divided into a series of individual blocks representing local regions of the flow field. The employed grid generation scheme provides local refinement of each block, yet ensures one-to-one matching of grid points on the surfaces of adjoining blocks. For each of the blocks, either potential or Euler equations can be solved. For every block, the conservation of mass equation is solved to determine phi. For blocks with rotationality, two additional equations for determining S and eta are solved. The basic steps of the developed solution scheme are presented. The computational considerations involved in utilizing the present scheme are demonstrated with sample problems. Author

**A86-38444*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THREE-DIMENSIONAL, CONSERVATIVE, EULER COMPUTATIONS USING PATCHED GRID SYSTEMS AND EXPLICIT METHODS**

K. A. HESSENIUS and M. M. RAI (NASA, Ames Research Center, Moffett Field, CA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 22 p. refs
(AIAA PAPER 86-1081)

The method of 'zonal approach' (in which the flow field is partitioned into regions with independent grids) for computation of flow over complex geometries, such as aircraft configuration, requires application of a grid-interfacing procedure. A three-dimensional conservative, boundary scheme for patched grids, applicable in generalized coordinates for arbitrary point distributions on a planar zonal surface is presented. The computation technique is derived within the framework of the Osher (1983) upwind scheme, using Euler equations. The three-dimensional interfacing method is applied to the computation of flow about a wing-canard combination using a two-zone, patched grid. I.S.

**A86-38445#**

**TRANSONIC FLOW SOLUTIONS ON A BLUNT, FINNED BODY OF REVOLUTION USING THE EULER EQUATIONS**

L. E. LIJEWSKI (USAF, Armament Laboratory, Eglin AFB, FL) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 10 p. refs
(AIAA PAPER 86-1082)

Pressure distribution and force and moment calculations are presented for a cruciform, finned body of revolution at angles of attack up to 15 deg. Near sonic conditions at Mach 0.95 are successfully predicted, and preliminary design quality force and moment coefficients are calculated. Crossflow velocity vector plots are presented to substantiate the complex flowfield at angle of attack. Strong vortical flow is captured up to 9-deg angle of attack. An elliptic grid generator and explicit upwind Euler solver were used on a CRAY-XMP to obtain results presented. The paper illustrates the inviscid code's capability to predict aerodynamic characteristics on a geometrically complex configuration at near sonic conditions and moderate angles of attack. Author

**A86-38446#**

**TRANSONIC POTENTIAL FLOW CALCULATIONS BY TWO ARTIFICIAL DENSITY METHODS**

G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) and A. JAMESON (Princeton University, NJ) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 8 p. refs
(AIAA PAPER 86-1084)

A steady transonic flow over an airfoil is computed by solving the full potential equation discretized over a contour-fitting grid in full conservation form. Near shock waves, the density is corrected to account for the rise in entropy in the region. A multigrid alternating direction method is used to drive the iteration. In supersonic flow regions, artificial dissipation is introduced either by a flux biasing scheme or by a density biasing scheme. The two schemes are second order accurate, while the density biasing scheme is second order accurate throughout the flow field except for a small region near shock waves. Results of calculations with the two schemes show that the flux biasing scheme gives a sharper resolution of the shock than the density biasing scheme when the shock itself is weak. As shock strength increases, the shock-capturing abilities of the two schemes become equal. Throughout the range of cases tested, the two schemes exhibited comparable speed and robustness. Author

**A86-38447*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### EFFECTS OF WIND-TUNNEL NOISE ON SWEPT-CYLINDER TRANSITION AT MACH 3.5

T. R. CREEL, JR., I. E. BECKWITH, and F.-J. CHEN (NASA, Langley Research Center, Hampton, VA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 20 p. refs
(AIAA PAPER 86-1085)

Transition data are reported for circular cylinders at swept angles of 45 and 60 degrees in the Mach 3.5 pilot-low-disturbance tunnel where free-stream noise levels are varied from approximately .05-0.5 percent in terms of the rms fluctuating pressure normalized by the mean static pressure. Results indicate that end plate or boundary layer trip disturbances at the upstream end of the cylinders cause turbulent flow along the entire test Reynolds number range of 10-170 thousand per inch. With all end plate and trip disturbances removed, transition at the attachment lines occurred at free-stream Reynolds numbers based on diameters of about 70-80 thousand, independent of stream noise levels. The installation of small trips on the attachement lines caused transition at lower Reynolds numbers, depending on both the roughness height and the wind tunnel noise level. R.R.

**A86-38448*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### EFFECTS OF CONE SURFACE WAVINESS AND FREESTREAM NOISE ON TRANSITION IN SUPERSONIC FLOW

E. L. MORRISETTE, T. R. CREEL, JR., and F.-J. CHEN (NASA, Langley Research Center, Hampton, VA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 7 p. refs
(AIAA PAPER 86-1086)

A comparison of transition on wavy-wall and smooth-wall cones in a Mach 3.5 wind tunnel is made under conditions of either low freestream noise (quiet flow) or high freestream noise (noisy flow). The noisy flow compares to that found in conventional wind tunnels while the quiet flow gives transitional Reynolds numbers on smooth sharp cones comparable to those found in flight. The waves were found to have a much smaller effect on transition than similar sized trip wires. A satisfactory correlating parameter for the effect of waves on transition was simply the wave height-to-length ratio. A given value of this ratio was found to cause the same percentage change in transition location in quiet and noisy flows. Author

**A86-38449#**

### LAMINAR BOUNDARY LAYER STABILITY EXPERIMENTS ON A CONE AT MACH 8. IV - ON UNIT REYNOLDS NUMBER AND ENVIRONMENTAL EFFECTS

K. F. STETSON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), E. R. THOMPSON (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN), J. C. DONALDSON, and L. G. SILER (Calspan Field Servces, Inc., Arnold Air Force Station, TN) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 29 p. refs
(AIAA PAPER 86-1087)

Hot wire anemometry is used to experimentally investigate the laminar boundary layer stability of a sharp, 7-deg half angle cone at a freestream Mach value of 8, with attention to the influences of the disturbance environment and unit Reynolds number on boundary layer disturbance growth. The spectral content of the environmental disturbances, and the upper frequency limit for excitation of the boundary layer disturbances are noted to be especially important, with the most important of the environmental disturbances being those of the same frequency as the most unstable boundary layer frequencies. Changing the unit Reynolds number by a factor of 4 did not change the stability characteristics of the boundary layer for frequencies at which environmental excitation was adequate. O.C.

**A86-38450#**

### WALL COOLING EFFECTS ON HYPERSONIC BOUNDARY LAYER TRANSITION, M(1) = 7.5 - 15

H. T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY), R. E. SHEER, JR. (GE Research and Development Center, Schenectady, NY), and D. C. WISLER (GE Fluid Mechanics Laboratory, Evendale, OH) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 11 p. refs
(AIAA PAPER 86-1088)

An investigation was conducted in a hypersonic shock tunnel over a Mach number range of 7.5 to 15 to study the effect of wall cooling and surface roughness on laminar boundary layer transition of an 8-ft cone having a 10-deg angle. The stagnation temperature was held approximately constant at 2500 K throughout the investigation, to produce a model wall temperature to stagnation temperature ratio of 0.12. Fast response thin film surface heat transfer gauges were the primary instruments used to detect transition and the passage of turbulent bursts which always appeared at the beginning of the transition region. Pitot-tube, total temperature, and wedge probe heat transfer surveys were made through the boundary layer to verify the interpretation of the surface heat transfer results. The turbulent theory (which included both the density and velocity fluctuation terms) and the laminar theory agreed well with the experiment. The rate of increase for the beginning and end of transition Reynolds number becomes progressively less as freestream Mach number increases above 9. Decreasing the wall-to-stagnation temperature ratio from 0.214 to 0.12, for a 10-deg cone, did not affect the transition Reynolds number. Author

**A86-38456*#** JAI Associates, Mountain View, Calif.

### NUMERICAL SIMULATION OF TIP VORTICES OF WINGS IN SUBSONIC AND TRANSONIC FLOWS

G. R. SRINIVASAN (JAI Associates, Inc., Mountain View, CA), W. J. MCCROSKEY, J. D. BAEDER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and T. A. EDWARDS (NASA, Ames Research Center, Moffett Field, CA) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 25 p. refs
(Contract DAAG29-85-C-0002)
(AIAA PAPER 86-1095)

A multi block zonal algorithm which solves the thin-layer Navier-Stokes and the Euler equations is used to numerically simulate the formation and roll-up of the tip vortex in both subsonic and transonic flows. Four test cases which used small and large aspect ratio wings have been considered to examine the influence of the tip-cap shape, the tip planform and the free-stream Mach number. It appears that both the tip-planform and the tip-cap shape have some influence on the formation of the tip vortex, but its subsequent roll-up seems to be more influenced by the tip-planform shape. In general, a good definition of the formation and the roll-up of the tip vortex has been observed for all the cases considered here. Comparions of the numerical results with the limited, available experimental data show good agreement with both the surface pressures and the tip-vortex strength. Author

**A86-38457#**
**VISUALIZATION OF WING TIP VORTICES IN UNSTEADY AND STEADY WIND**
P. FREYMUTH, F. FINAISH, and W. BANK (Colorado, University, Boulder) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 12 p. refs
(Contract F49620-84-C-0065)
(AIAA PAPER 86-1096)

Streakline visualization by smoke near the tip of a rectangular half-wing which protrudes into the center of a wind tunnel test section from the top wall has been conducted at angles of attack 10 deg, 20 deg and 30 deg. The tunnel was either operated in the mode of an accelerating flow starting from rest or in a steady speed mode. The visualizations suggest a novel wing tip vortex system. Vorticity generated at the pressure side of the wing forms a conical tip vortex with its apex at the front corner of wing tip. Another conical tip vortex with the same apex location forms further inboard from vorticity generated at the suction side of the wing. Author

**A86-38464#**
**THREE-DIMENSIONAL UNSTEADY FLOW FIELDS ELICITED BY A PITCHING FORWARD SWEPT WING**
J. ASHWORTH, M. WALTRIP, and M. W. LUTTGES (Colorado, University, Boulder) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 10 p. refs
(Contract F49620-83-K-0009)
(AIAA PAPER 86-1104)

The three-dimensional flow field about a forward swept, NACA 0015 wing was studied using multiple exposure, phase-locked flow visualization. The flow was viewed from orthogonal perspectives. The wing was oscillated sinusoidally in pitch while stroboscopic photography was used to record the pitching-dependent alterations in flow field structure. Flow interactions were visualized in discrete fashion for a variety of spanwise views, using different k values and mean angle of attack. The major flow field characteristics of the dynamically oscillating swept forward wing were the tip and the leading edge vortices. The strong helical tip flow vortices dominated most of the observed flow structures near the wing tip across all test conditions. The far inboard span locations were dominated by flows related to the leading edge vortex. Whereas the swept forward wing elicits flow structures that are qualitatively predictable from previous research, the magnitude and interaction of these flow structures were quite different. The spatial domain of the flows was quite pronounced and seemed to be specific to the wing geometry of the test configuration. Author

**A86-38465#**
**UNSTEADY AERODYNAMICS OF RAPIDLY PITCHED AIRFOILS**
J. C. WU, I. H. TUNCER (Georgia Institute of Technology, Atlanta), and C. M. WANG AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 14 p. refs
(Contract AF-AFOSR-86-0121)
(AIAA PAPER 86-1105)

The problem of dynamic stall of an airfoil pitched rapidly at a constant rate to large angles of attack is studied computationally. Flow patterns, pressure distributions on the airfoil surface, histories of the lift, the drag and the moment experienced by the airfoil are computed and examined. The computed results are shown to be in good agreement with available experimental data. Author

**A86-38473*#** Science Applications International Corp., Princeton, N.J.
**PROGRESS IN THE DEVELOPMENT OF PARABOLIZED NAVIER-STOKES (PNS) METHODOLOGY FOR ANALYZING PROPULSIVE JET MIXING PROBLEMS**
S. M. DASH, D. E. WOLF, N. SINHA, and S. H. LEE (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) AIAA and ASME, Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 24 p. refs
(Contract NAS1-16535)
(AIAA PAPER 86-1115)

A brief review of 2D PNS methodology is first presented which describes the specialized features of supersonic shock-capturing and subsonic pressure-split models required for the analysis of aircraft, rocket and scramjet jet mixing problems. These features include techniques for dealing with various types of embedded and interfacing subsonic regions, the inclusion of finite-rate chemistry and the direct-coupling with potential flow solutions. Preliminary 3D extensions of this PNS methodology geared to supersonic and subsonic rectangular free jet mixing problems are also reviewed. New 3D PNS work will be described which includes the development of a hybrid supersonic/subsonic free jet mixing model, and, a supersonic model geared to the analysis of turbulent mixing and combustion processes occurring in scramjet combustor/nozzle flowfields. Author

**A86-38502*** Texas A&M Univ., College Station.
**AN INVESTIGATION OF THE EFFECTS OF THE PROPELLER SLIPSTREAM OF A LAMINAR WING BOUNDARY LAYER**
R. M. HOWARD, S. J. MILEY (Texas A & M University, College Station), and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1-12. refs
(Contract NAG1-344)
(SAE PAPER 850859)

A research program is in progress to study the effects of the propeller slipstream on natural laminar flow. Flight and wind tunnel measurements of the wing boundary layer have been made using hot-film velocity sensor probes. The results show the boundary layer, at any given point, to alternate between laminar and turbulent states. This cyclic behavior is due to periodic external flow turbulence originating from the viscous wake of the propeller blades. Analytic studies show the cyclic laminar/turbulent boundary layer to result in a significantly lower wing section drag than a fully turbulent boundary layer. The application of natural laminar flow design philosophy yields drag reduction benefits in the slipstream affected regions of the airframe, as well as the unaffected regions. Author

**A86-38503**
**AN EXPERIMENTAL STUDY OF A GENERAL AVIATION SINGLE-ENGINE AIRCRAFT UTILIZING A NATURAL LAMINAR FLOW WING**
C. OSTOWARI and D. A. NAIK (Texas A & M University, College Station) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 23-35. refs
(SAE PAPER 850861)

Force and moment measurements, and surface flow patterns have been obtained for a one-fifth scale model of a single-engine general aviation aircraft utilizing a 15-percent thick natural laminar flow wing section. The data is for typical pre- and poststall angles of attack, aircraft yaw attitudes, surface roughness and Reynolds number conditions. Results from a separate study of the wing alone are also given for comparison. This comparison shows that the fuselage/tail assembly acts as a lifting body. The aerodynamic characteristics show marked deterioration with increasing surface roughness. In addition, the studies indicate that the transition on the wing is characterized by laminar short bubble separation. The aerodynamic characteristics are somewhat unaffected by the presence of minitufts. The flow visualization photographs clearly show the transition and separation regions, and document the effects of variations in angle of attack and yaw on wing body interference. Author

**A86-38505**

**NATURAL LAMINAR FLOW AND REGIONAL AIRCRAFT**

K. L. WILLIAMS, P. VIJGEN, and J. ROSKAM (Kansas, University, Lawrence) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 61-71. refs
(SAE PAPER 850864)

Work done under a NASA-Langley grant at the University of Kansas Flight Research Laboratory in the area of natural laminar flow and regional aircraft is described. The focus is on the application of natural laminar flow over various major wetted areas. In particular, efforts were concentrated on analyzing the potential benefits of achieving extensive laminar flow on the wing, empennage, and fuselage. The effect of the presence of large amounts of laminar flow is evaluated in terms of performance and efficiency improvement over an all-turbulent baseline aircraft. An introduction is given to the concept of regional aircraft, and the aerodynamic characteristics are compared to those of other airplane classes. Some recent aerodynamic developments are presented that justify, to a certain extent, the assumptions made concerning the amount of natural laminar flow that is possible for each surface. Application of a cruise/climb flap to advanced medium-speed natural laminar flow airfoils is also discussed. Author

**A86-38507**

**ANALYTICAL STUDY OF THREE-SURFACE LIFTING SYSTEMS**

K. ROKHSAZ and B. P. SELBERG (Missouri-Rolla, University, Rolla) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 85-94. refs
(SAE PAPER 850866)

Conventional, canard, and three surface aircraft configurations are investigated analytically to determine each configuration's induced drag, as well as the pressure and viscous drag. A vortex panel method in conjunction with momentum integral boundary layer method is used to predict inviscid and viscous characteristics. Vortex lattice methods are used to trim the aircraft as well as to predict the induced drag of each configuration. Viscous and induced drag results are presented for two different payloads, a six-place and a twelve-place configuration. For both payloads the conventional configuration had the highest lift over drag. However, the canard and the three surface were close enough to warrant consideration based on other criteria. Author

**A86-38880#**

**LIFTING SURFACE THEORY FOR THE REST OF US**

B. VAN NIEKERK (Stanford University, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 739-745. refs
(Contract AF-AFOSR-84-0099)
(AIAA PAPER 86-1025)

A rational approach to lifting theory is presented. It is shown that a special numerical integration rule can be found to directly compute the finite part of the characteristic double pole singular integrals found in subsonic lifting surface theories. This is coupled with an optimum weighted residual method which ensures rapid convergence of the aerodynamic generalized forces. The versatility of these techniques is demonstrated by computing the time accurate unsteady airloads on three-dimensional wings. Author

**A86-38897*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**UNSTEADY TRANSONIC FLOW CALCULATIONS FOR WING-FUSELAGE CONFIGURATIONS**

J. T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 142-155. refs
(AIAA PAPER 86-0862)

The development of the XTRAN3S wing fuselage capability for predicting transonic unsteady aerodynamic loads for aeroplastic applications is described. The modifications of the XTRAN3S code, and XTRAN3S fuselage modeling based on an alternating-direction implicit finite-difference algorithm for solving a modified transonic small-disturbance equation, are analyzed. The XTRAN3S transonic code is applied to the steady and unsteady calculations for three wing-fuselage configurations and a transport-type wing-fuselage model. The effects of fuselage aerodynamic interference on the transonic unsteady air load and flutter characteristics of wings are investigated. Good correlation is detected for the calculated and experimental pressure distributions of the models confirming the validity of the code. I.F.

**A86-38898*#** Purdue Univ., West Lafayette, Ind.

**NONISENTROPIC UNSTEADY THREE DIMENSIONAL SMALL DISTURBANCE POTENTIAL THEORY**

M. D. GIBBONS, M. H. WILLIAMS (Purdue University, West Lafayette, IN), and W. WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 156-165. refs
(Contract NAG1-372)
(AIAA PAPER 86-0863)

Nonisentropic modifications to the three-dimensional transonic small disturbance (TSD) theory, which allows for more accurate modeling of transonic flow fields, are described. The modified flux equation and entropy corrections are presented; the Engquist-Osher differencing (1980) is added to the solution algorithm in order to eliminate the velocity overshoots upstream of shocks. The modified theory is tested in the XTRAN3S finite difference computer code. Steady flows over a rectangular NACA 0012 wing with an aspect ratio of 12 are calculated and compared to Euler equation solutions; good correlation is observed between the data and the modified TSD theory provides more accurate data, particularly for the lift curve slope. The nonisentropic theory is evaluated on an RAE tailplane model for steady and unsteady flows and the modified theory results agree well with the experimental data. I.F.

**A86-38900*#** California Univ., Los Angeles.

**A NEW APPROACH TO FINITE STATE MODELLING OF UNSTEADY AERODYNAMICS**

C. VENKATESAN and P. P. FRIEDMANN (California, University, Los Angeles) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 178-191. refs
(Contract NAG2-209)
(AIAA PAPER 86-0865)

This paper presents a novel technique for formulating a high quality finite state unsteady aerodynamic model by applying Bode plot methods, used in control engineering. Indicial response functions for both fixed wing and rotary wing applications are obtained using these finite state unsteady aerodynamic models. It is shown that the rotary wing indicial response function has a fundamentally different characteristic when compared to fixed wing indicial response. The rotary wing indicial response function is oscillatory in nature while the fixed wing indicial response function is nonoscillatory. Furthermore it should be emphasized that this is the first that a rotary-wing indicial response function has been presented in the literature. Author

**A86-38901#**

**A CALCULATION METHOD FOR UNSTEADY AERODYNAMIC FORCES IN THE LAPLACE DOMAIN AND ITS APPLICATION TO ROOT LOCI**

T. UEDA (National Aerospace Laboratory, Chofu, Japan) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 192-200. refs
(AIAA PAPER 86-0866)

A method for obtaining unsteady aerodynamic forces acting on a subsonic thin finite wing is presented. The unsteady forces are numerically evaluated as a function of the Laplace transform variable s which corresponds to arbitrary, as well as harmonic, motion of a wing. Computation is possible on the entire s-plane except for a branch cut on the negative real axis. The method proposed is based on the doublet point method so that the wing planform may be arbitrary including practical control surfaces. The exact forces obtained for the Laplace variable are applied to determine root loci of a wind tunnel wing model. Comparison of the results with those by the finite state aerodynamic modeling shows good accuracy of Roger's approximation. The effect of compressibility is also examined to reveal that the aerodynamic root does exist for a high subsonic flow range. Author

**A86-38912#**

**AN EXPERIMENTAL STUDY OF THE AERODYNAMICS OF INCIPIENT TORSIONAL STALL FLUTTER**

F. O. CARTA and P. F. LORBER (United Technologies Research Center, East Hartford, CT) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 303-313. refs
(AIAA PAPER 86-0901)

An experimental study has been made of the aerodynamics of small amplitude airfoil torsional oscillations near stall to examine the mechanism that leads to stall flutter on propeller blades. An airfoil was oscillated in pitch at amplitudes of 0.5, 2.0, and 4.0 deg. Time histories of the unsteady surface pressures show that stall initiation and reattachment at low amplitudes are determined not only by kinematic conditions but also by the presence or absence of random effects such as gusts or vibrations. In contrast to the results at higher amplitude, hysteresis loops at low amplitude near stall are dominated by a central destabilizing subloop, so that the aerodynamic pitch damping per unit amplitude has a maximum negative value near an amplitude of 2 deg. This implies that small amplitude oscillations near stall may be extremely unstable. The measured aerodynamic damping is used in a model calculation to predict the growth rate of torsional oscillations of an airfoil free to oscillate in pitch. An initial small torsional disturbance grows rapidly and then asymptotically approaches a limiting amplitude, similar to behavior observed during stall flutter. Author

**A86-38913*#** Purdue Univ., West Lafayette, Ind.

**A COMPUTATIONAL TRANSONIC FLUTTER BOUNDARY TRACKING PROCEDURE**

J. W. GALLMAN, T. Y. YANG (Purdue University, West Lafayette, IN), and J. T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 314-324. refs
(Contract NAG1-372)
(AIAA PAPER 86-0902)

An automated flutter boundary tracking procedure is presented for the efficient calculation of transonic flutter boundaries. The new procedure uses aeroelastic responses to march along the boundary by taking steps in speed and Mach number, thereby reducing the number of response calculations previously required to determine a transonic flutter boundary. The tracking procedure reduces computational costs since only two response calculations are required per Mach number and provides a complete boundary in a single job submission. Flutter boundary results are presented for a typical airfoil section oscillating with pitch and plunge degrees of freedom. These transonic flutter boundaries are in good agreement with 'exact' boundaries calculated using the conventional time-marching method. The tracking procedure was also extended to include static aeroelastic twist as a simulation of the static deformation of a wing and thus contains all of the essential features that are required to apply it to practical three-dimensional cases. Application of the procedure is also made to flutter boundaries as a function of structural parameters, the capability of which is useful as a design tool. Author

**A86-38948*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**TRANSONIC AEROELASTICITY OF WINGS WITH TIP STORES**

G. P. GURUSWAMY (Sterling Software/Informatics, Palo Alto, CA), P. M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA), and E. L. TU IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 672-683. USAF-supported research. refs
(AIAA PAPER 86-1007)

The presence of tip stores influences both aerodynamic and aeroelastic performances of wings. Such effects are more pronounced in the transonic regime. In this study, transonic aeroelasticity of wings with tip stores is studied for the first time by a theoretical method using the unsteady-small disturbance transonic aerodynamic equations coupled with modal structural equations of motion. The aerodynamic and structural equations of motion are simultaneously integrated by a time-accurate numerical scheme. To validate the tip store simulation, aeroelastic computations are made for a typical rectangular wing with a tip store and results are correlated with available wind tunnel data for the corresponding wing without a tip store at various flight conditions. Aeroelastic computations are also made for a typical fighter wing with a tip store. Present computations show that it is important to account for the aerodynamics of the tip store, particularly in the transonic regime where the tip store can make the wing aeroelastically unstable. Author

**A86-38971**

**THE INDIRECT BOUNDARY INTEGRAL FORMULATION FOR ELLIPTIC, HYPERBOLIC AND NON-LINEAR FLUID FLOWS**

B. HUNT and B. L. HEWITT (British Aerospace, PLC, Aircraft Group, Preston, England) IN: Developments in boundary element methods - 4 . London and New York, Elsevier Applied Science Publishers, 1986, p. 227-339. refs

Three distinct aspects of the boundary integral method for fluid flows are examined in detail. The fundamental physics are discussed first, showing how one of the practical boundary integral models employed in routine aerodynamic applications for incompressible irrotational flows may be interpreted in purely physical terms. Then, a detailed mathematical analysis of the linearized elliptic formulation is given which leads to the so-called 'indirect' boundary integral formulation permitting source and vorticity distributions of very low order to be used to give accurate by economical solutions. Finally, an extensive discussion of the linearized hyperbolic flow problem indicates how methodologies have been developed which allow boundary integral formulations to be successfully applied to the hyperbolic flow problem. C.D.

**A86-39052#**

**UNSTEADY VORTICAL FLOW AROUND THREE-DIMENSIONAL LIFTING SURFACES**

M. GAD-EL-HAK (Flow Research Co., Kent, WA) and C.-M. HO (Southern California, University, Los Angeles, CA) AIAA Journal (ISSN 0001-1452), vol. 24, May 1986, p. 713-721. Previously cited in issue 07, p. 836, Accession no. A85-19476. refs
(Contract F49620-82-C-0020)

**A86-39053*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**COMPUTATION OF TRANSONIC FLOW ABOUT HELICOPTER ROTOR BLADES**
R. ARIELI, M. E. TAUBER (NASA, Ames Research Center, Moffett Field, CA), D. A. SAUNDERS (Informatics General Corp., Palo Alto, CA), and D. A. CAUGHEY (Cornell University, Ithaca, NY) AIAA Journal (ISSN 0001-1452), vol. 24, May 1986, p. 722-727. refs

An inviscid, nonconservative, three-dimensional full-potential flow code, ROT22, has been developed for computing the quasi-steady flow about a lifting rotor blade. The code is valid throughout the subsonic and transonic regime. Calculations from the code are compared with detailed laser velocimeter measurements made in the tip region of a nonlifting rotor at a tip Mach number of 0.95 and zero advance ratio. In addition, comparisons are made with chordwise surface pressure measurements obtained in a wind tunnel for a nonlifting rotor blade at transonic tip speeds at advance ratios from 0.40 to 0.50. The overall agreement between theoretical calculations and experiment is very good. A typical run on a CRAY X-MP computer requires about 30 CPU seconds for one rotor position at transonic tip speed. Author

**A86-39054#**
**A METHOD FOR THE DESIGN OF SHOCK-FREE SLENDER BODIES OF REVOLUTION**
A. A. HASSAN (Arizona State University, Tempe) AIAA Journal (ISSN 0001-1452), vol. 24, May 1986, p. 728-734. refs

A numerical procedure is presented for the design of shock-free supercritical slender bodies of revolution. The procedure relies on the fact that for small disturbances a hodograph-like transformation (not known a priori) can be applied to the axisymmetric potential equation. This results in a set of two coupled Poisson equations defined on a common rectangular domain. With the special variables used, the system of coupled equations for the subsonic portion of the flow is solved iteratively using a fast Poisson solver. This in turn, defines the mapping of the subsonic or subsonic-sonic boundary in the physical plane. For supercritical flows, the supersonic portion of the flow is calculated from data on the sonic line using an axisymmetric characteristic calculation. This is followed by a map to the physical plane to determine the shape of the body under the sonic bubble. Examples of shock-free supercritical slender body designs are presented and show good agreement with the direct computation of the flow past the designed slender bodies. Author

**A86-39090*#** United Technologies Research Center, East Hartford, Conn.
**THREE-DIMENSIONAL INVISCID FLOW IN MIXERS. I - MIXER ANALYSIS USING A CARTESIAN GRID**
T. J. BARBER (United Technologies Research Center, East Hartford, CT), G. L. MULLER, S. M. RAMSAY (United Technologies Corp., Pratt and Whitney, East Hartford, CT), and E. M. MURMAN (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, May-June 1986, p. 275-281. Previously cited in issue 07, p. 837, Accession no. A85-19510. refs
(Contract NAS3-23039)

**A86-39657**
**HEAT TRANSFER AND DRAG OF A BODY IN THE FAR SUPERSONIC WAKE [TEPLOOBMEN I SOPROTIVLENIE TELA, RASPOLOZHENNOGO V DAL'NEM SVERKHZVUKOVOM SLEDE]**
I. G. EREMEITSEV and N. N. PILIUGIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1986, p. 60-67. In Russian. refs

Generalized formulas are obtained which provide a convenient way to make mass calculations of convective heat fluxes toward bodies and their drag in wake-type inhomogeneous flows. Attention is also given to the formation of a return-circulation zone at the frontal surface of the body. A comparison of the results obtained with real parameters of a far wake has shown that the nonseparated flow region is sufficiently large. The effect of flow inhomogeneity on the local and integral flow characteristics is examined. V.L.

**A86-39660**
**LIFTING BODIES DESIGNED FOR FLOW BEHIND AXISYMMETRIC CONICAL SHOCK WAVES [NESUSHCHIE TELA, POSTROENNYE NA TECHENIIA ZA OSESIMMETRICHNYMI KONICHESKIMI SKACHKAMI UPLOTNENIIA]**
V. I. VORONIN and A. I. SHVETS Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1986, p. 135-138. In Russian.

A numerical solution is presented for the problem of flow past lifting bodies designed for flow behind axisymmetric conical shock waves with half-angles of taper of 9.5 and 18 deg. The leading edge of the bodies considered here is located below the apex of the conical shock wave; the upper surfaces of the bodies are formed by intersecting planes parallel to the velocity vector of the oncoming flow. The solution presented here has been implemented in computer software. Results of calculations are presented in graphic form. V.L.

**A86-39762#**
**RECURRENT IDENTIFICATION OF UNSTEADY AERODYNAMIC FORCES OF ELASTIC VEHICLES**
X. XIONG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, April 1986, p. 121-127. In Chinese, with abstract in English.

A method for identifying the unsteady aerodynamic forces of elastic vehicles is presented. A standard measurement equation satisfied by aerodynamic indicial functions is derived from longitudinal small-disturbance equations of elastic vehicles with unsteady aerodynamic forces described by Duhamel's integral. The discrete values of aerodynamic indicial functions in time domain are obtained by using the recurrent filter technique. In comparison with other methods, this method has the following advantages: (1) the ability to take the effects of structural deformation into account; (2) the capability to identify the unsteady aerodynamic parameters of the whole vehicle; (3) ease in collecting initial data; and (4) simplicity of calculations. Finally, some results of the preliminary calculation for a vehicle are given. Author

**N86-26285*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**PLUME CHARACTERISTICS OF SINGLE-STREAM AND DUAL-FLOW CONVENTIONAL AND INVERTED-PROFILE NOZZLES AT EQUAL THRUST**
U. H. VONGLAHN and J. H. GOODYKOONTZ 1986 39 p refs Presented at the 4th Applied Aerodynamics Conference, San Diego, Calif. 9-11 Jun. 1986; sponsored by AIAA
(NASA-TM-87323; E-3060; NAS 1.15:87323; AIAA-86-1809)
Avail: NTIS HC A03/MF A01 CSCL 01A

The plume velocity and temperature decay rates of single-stream, conventional dual-flow and inverted-profile dual-flow nozzles are compared at equal values of ideal thrust over a wide range of flow conditions. The comparisons are made in terms of constant velocity and temperature contour maps. The results show that both dual-flow nozzle types have much greater plume velocity and temperature decay rates than those of equivalent thrust single-stream nozzles when the respective secondary flows were at ambient temperature. With hot secondary flows, the inverted-profile dual-flow plumes decayed significantly faster than those of single-stream nozzles; however, the decay rates for the conventional dual-flow streams were about the same as those for the single-stream nozzles. Consequently, with hot secondary flows, the inverted-profile dual-flow plumes decayed much faster than the conventional dual-flow plumes at equal thrust. Author

**N86-26288*#** United Technologies Research Center, East Hartford, Conn.

**ANALYSIS OF TRANSITIONAL SEPARATION BUBBLES ON INFINITE SWEPT WINGS**

R. L. DAVIS and J. E. CARTER Washington Jun. 1986 39 p refs
(Contract NAS1-16585)
(NASA-CR-3956; NAS 1.26:3956) Avail: NTIS HC A03/MF A01 CSCL 01A

A previously developed two-dimensional local inviscid-viscous interaction technique for the analysis of airfoil transitional separation bubbles, ALESEP (Airfoil Leading Edge Separation), has been extended for the calculation of transitional separation bubbles over infinite swept wings. As part of this effort, Roberts' empirical correlation, which is interpreted as a separated flow empirical extension of Mack's stability theory for attached flows, has been incorporated into the ALESEP procedure for the prediction of the transition location within the separation bubble. In addition, the viscous procedure used in the ALESEP techniques has been modified to allow for wall suction. A series of two-dimensional calculations is presented as a verification of the prediction capability of the interaction techniques with the Roberts' transition model. Numerical tests have shown that this two-dimensional natural transition correlation may also be applied to transitional separation bubbles over infinite swept wings. Results of the interaction procedure are compared with Horton's detailed experimental data for separated flow over a swept plate which demonstrates the accuracy of the present technique. Wall suction has been applied to a similar interaction calculation to demonstrate its effect on the separation bubble. The principal conclusion of this paper is that the prediction of transitional separation bubbles over two-dimensional or infinite swept geometries is now possible using the present interacting boundary layer approach. Author

**N86-26289*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**TABLES FOR CORRECTING AIRFOIL DATA OBTAINED IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL FOR SIDEWALL BOUNDARY-LAYER EFFECTS**

R. V. JENKINS and J. B. ADCOCK Jun. 1986 16 p refs
(NASA-TM-87723; NAS 1.15:87723) Avail: NTIS HC A02/MF A01 CSCL 01A

Tables for correcting airfoil data taken in the Langley 0.3-meter Transonic Cryogenic Tunnel for the presence of sidewall boundary layer are presented. The corrected Mach number and the correction factor are minutely altered by a 20 percent change in the boundary layer virtual origin distance. The sidewall boundary layer displacement thicknesses measured for perforated sidewall inserts and without boundary layer removal agree with the values calculated for solid sidewalls. Author

**N86-26291#** Woodrow Wilson International Center for Scholars, Washington, D.C. Asia Program.

**THE EFFECTS ON ROTOR NONUNIFORM INFLOW HARMONIC CONTENT OF UNEVEN CIRCUMFERENTIAL DISTRIBUTION OF JET ENGINE INLET GUIDE VANES**

M. R. HINSMAN Jan. 1986 39 p refs
(Contract N00024-85-C-6041)
(AD-A164629) Avail: NTIS HC A03/MF A01 CSCL 20D

A computative parametric study was conducted to investigate the effects of vane section geometry, vane number, and primarily, uneven circumferential vane spacing on the harmonic content of the wake field produced by a row of jet engine inlet guide vanes (IGV). As parameters were varied, the harmonic content of the resulting wake field was analyzed for its potential effect on unsteady pressures at the rotor. A semi-empirical model is presented which was used to generate the two-dimensional flow field downstream of the IGV plane. Results show that uneven angular spacing of IGV should not be employed for reducing unsteady pressures experienced by the rotor. In fact, manufacturing tolerances, relative to IGV angular location, of evenly spaced vanes should be minimized to minimize unsteady pressures. GRA

**N86-26293#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**LAMINAR AND TURBULENT BOUNDARY-LAYER CALCULATIONS ON THE LEEWARD SURFACE OF A SLENDER DELTA WING AT INCIDENCE**

A. C. DEBRUIN 13 Apr. 1984 20 p Submitted for publication
(NLR-MP-84040-U; B8577053; ESA-86-96969) Avail: NTIS HC A02/MF A01

The boundary layer on the leeward surface of a slender delta wing at incidence was calculated for fully laminar flow and the case with artificial boundary layer tripping at the 50% semispan location. The behavior of the predicted boundary layer properties is qualitatively in good agreement with experimental observations. The rather large difference between the potential flow and experimental pressure distribution causes a discrepancy between the predicted and the experimentally observed location of secondary separation. It is expected that the potential flow pressure distribution can be improved when the leading-edge and the secondary separation vortex sheet are correctly modeled in the potential flow calculation method. ESA

**N86-27182*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**UNSTEADY AERODYNAMICS-FUNDAMENTALS AND APPLICATIONS TO AIRCRAFT DYNAMICS**

D. G. MABEY (Royal Aircraft Establishment, Bedford, England) and J. R. CHAMBERS 1985 18 p
(NASA-TM-88768; NAS 1.15:88768; AGARD-AR-222; ISBN-92-835-1515-3) Avail: NTIS HC A02/MF A01 CSCL 01A

From May 6 to 9, 1985, the Fluid Dynamics Panel and Flight Mechanics Panel of AGARD jointly arranged a Symposium on Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics at the Stadthall, Gottingen, West Germany. This Symposium was organized by an international program committee chaired by Dr K. J. Orlik-Ruckemann of the Fluid Dynamics Panel. The program consisted of five sessions grouped in two parts: (1) Fundamentals of Unsteady Aerodynamics; and (2) Applications to Aircraft Dynamics. The 35 papers presented at the 4 day meeting are published in AGARD CP 386 and listed in the Appendix. As the papers are already available and cover a very wide field, the evaluators have offered brief comments on every paper, followed by an overall evaluation of the meeting, together with some general conclusions and recommendations. Author

**N86-27184#** National Aerospace Lab., Tokyo (Japan). Second Aerodynamics Div.

**COMPUTATION OF 3-DIMENSIONAL VISCOUS TRANSONIC FLOWS USING THE LU-ADI FACTORED SCHEME**

K. FUJII and S. OBAYASHI Nov. 1985 20 p
(NAL-TR-889T; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The LU-ADI (lower/upper block diagonal - alternating direction implicit) factored scheme was successfully applied to solve the three-dimensional compressible thin layer Navier-Stokes equations. The computations are carried out for the slightly supersonic flow over a hemispheric cylinder at high incidence and for the transonic flow over a swept wing. To simulate these complicated flow fields, fine grid distributions of up to about 200,000 points were used on the Japanese supercomputer of 1 GFLOPS. The total cpu time for each case was less than two hours. The results for the flow over a hemispheric cylinder at high incidence revealed the existence of the shock wave and the detailed structure of the vortical flow field on the leeward side. The result for the flow over the swept wing shows that the three-dimensional shock induced separation is well captured. These results indicate the capability of the present code to make three-dimensional complicated flow field simulations; and the application of the present code to the more practical flow fields such as transonic flows over the wing or the wing-body combination of the transportation aircraft is very promising. Even simulation over the whole aircraft may soon be possible. Author

**N86-27185#** National Aerospace Lab., Tokyo (Japan).
**WIND TUNNEL TEST AND ANALYSIS ON GUST LOAD ALLEVIATION OF A HIGH-ASPECT-RATIO WING**
Nov. 1985 60 p In JAPANESE; ENGLISH summary
(NAL-TR-890; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

Application of the active control technology to gust load alleviation problems was investigated both experimentally and analytically. Wind tunnel test were conducted for a high aspect ratio wing that assumes an energy efficient type of future transport. For these tests, National Aerospace Laboratory's low speed wind tunnel was equipped with a gust generator with hydraulic servo system. This generator generates turbulence by utilizing the tip vortices from the cantilevered double wings. Atmospheric turbulence was simulated in the tunnel according to the Dryden mathematical model. Control surfaces of the flexible wing model were actuated by a small dc electric motor embedded in the airfoil. A handy analog computer played the role of controller to drive control surfaces by the signals from two accelerometers and a strain gauge which was installed in the model as feedback sensors. Control laws were obtained by the optimal control theory with its performance index selected as the total energy of the system. Simple control laws based on the LQG theory demonstrated their effectiveness against realistic random gusts. At the end of the test, the flutter boundary of this model was determined for the configuration without active control. Author

**N86-27187#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
**AIRCRAFT DRAG PREDICTION AND REDUCTION. ADDENDUM 1: COMPUTATIONAL DRAG ANALYSES AND MINIMIZATION; MISSION IMPOSSIBLE?**
J. W. SLOOFF (National Aerospace Lab., Amsterdam, Netherlands) Apr. 1986 33 p Presented at Aircraft Drag Prediction and Reduction, Rhode Saint Genese, Belgium, 20-23 May 1985, and Hampton, Va., 5-8 Aug. 1985; sponsored by the von Karman Inst., AGARD, and NASA Langley Research Center
(AGARD-R-723-ADD-1; ISBN-92-835-1524-2) Avail: NTIS HC A03/MF A01

The Special Course on Aircraft Drag Prediction was sponsored by the AGARD Fluid Dynamics Panel and the von Karman Institute and presented at the von Karman Institute, Rhode-Saint-Genese, Belgium, on 20 to 23 May 1985 and at the NASA Langley Research Center, Hampton, Virginia, USA, 5 to 6 August 1985. The course began with a general review of drag reduction technology. Then the possibility of reduction of skin friction through control of laminar flow and through modification of the structure of the turbulence in the boundary layer were discussed. Methods for predicting and reducing the drag of external stores, of nacelles, of fuselage protuberances, and of fuselage afterbodies were then presented followed by discussion of transonic drag rise. The prediction of viscous and wave drag by a method matching inviscid flow calculations and boundary layer integral calculations, and the reduction of transonic drag through boundary layer control are also discussed. This volume comprises Paper No.9 Computational Drag Analyses and Minimization: Mission Impossible? which was not included in AGARD Report 723 (main volume). Author

**N86-27190*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**VORTEX FLOW AERODYNAMICS, VOLUME 1**
J. F. CAMPBELL, ed., R. F. OSBORN, ed. (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio), and J. T. FOUGHNER, JR., ed. Jul. 1986 404 p Conference held in Hampton, Va., 8-10 Oct. 1985
(NASA-CP-2416-VOL-1; L-16117; NAS 1.55:2416-VOL-1) Avail: NTIS HC A18/MF A01 CSCL 01A

Vortex modeling techniques and experimental studies of research configurations utilizing vortex flows are discussed. Also discussed are vortex flap investigations using generic and airplane research models and vortex flap theoretical analysis and design studies.

**N86-27191*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**VORTEX LIFT RESEARCH: EARLY CONTRIBUTIONS AND SOME CURRENT CHALLENGES**
E. C. POLHAMUS *In its* Vortex Flow Aerodynamics, Vol. 1 p 1-30 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

The trend towards slender wing aircraft for supersonic cruise and the early chronology of research directed towards their vortex-lift characteristics are briefly reviewed. An overview of the development of vortex-lift theoretical methods is presented, and some current computational and experimental challenges related to the viscous flow aspects of this vortex flow are discussed. Author

**N86-27192*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**LEADING-EDGE VORTEX RESEARCH: SOME NONPLANAR CONCEPTS AND CURRENT CHALLENGES**
J. F. CAMPBELL and R. F. OSBORN (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio) *In its* Vortex Flow Aerodynamics, Vol. 1 p 31-63 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

Some background information is provided for the Vortex Flow Aerodynamics Conference and that current slender wing airplanes do not use variable leading edge geometry to improve transonic drag polar is shown. Highlights of some of the initial studies combining wing camber, or flaps, with vortex flow are presented. Current vortex flap studies were reviewed to show that there is a large subsonic data base and that transonic and supersonic generic studies have begun. There is a need for validated flow field solvers to calculate vortex/shock interactions at transonic and supersonic speeds. Many important research opportunities exist for fundamental vortex flow investigations and for designing advanced fighter concepts. Author

**N86-27193*#** Kansas Univ., Lawrence. Dept. of Aerospace Engineering.
**EXTENSIONS OF THE CONCEPT OF SUCTION ANALOGY TO PREDICTION OF VORTEX LIFT EFFECT**
C. E. LAN *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 65-84 Jul. 1986
(Contract NSG-1629)
Avail: NTIS HC A18/MF A01 CSCL 01A

Flow field data for a double delta wing at low speed were used to determine the location of a vortex action point. The result was found to be consistent with what was determined for a delta wing. In supersonic flow, the action point location was determined empirically. For a wing with rounded leading edges, an assumption for initial vortex separation was shown to be equivalent to initial leading edge bubble separation for airfoils. A theoretical formulation by the section analogy to determine the delayed vortex separation on a cambered wing with rounded leading edges was presented. The method of suction analogy was further shown to be applicable to predicting the body vortex lift. Author

**N86-27194*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**RECENT EXTENSIONS TO THE FREE-VORTEX-SHEET THEORY FOR EXPANDED CONVERGENCE CAPABILITY**
J. M. LUCKRING, K. D. HOFFLER (Vigyan Research Associates, Inc., Hampton, Va.), and A. G. GRANTZ (Northrop Corp., Hawthorne, Calif.) *In its* Vortex Flow Aerodynamics, Vol. 1 p 85-114 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

A new version of the free vortex sheet formulation is presented which has greatly improved convergence characteristics for a broad range of geometries. The enhanced convergence properties were achieved largely with extended modeling capabilities of the leading edge vortex and the near field trailing wake. Results from the new code, designated FVS-1, are presented for a variety of configurations and flow conditions with emphasis on vortex flap applications. Author

**N86-27195*#** North Carolina State Univ., Raleigh.

**A DIRECT AND INVERSE BOUNDARY LAYER METHOD FOR SUBSONIC FLOW OVER DELTA WINGS**

S. H. WOODSON and F. R. DEJARNETTE *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 115-133 Jul. 1986
(Contract NCC1-22)
Avail: NTIS HC A18/MF A01 CSCL 01A

A new inverse boundary layer method is developed and applied to incompressible flows with laminar separation and reattachment. Test cases for two dimensional flows are computed and the results are compared with those of other inverse methods. One advantage of the present method is that the calculation of the inviscid velocities may be determined at each marching step without having to iterate. The inverse method was incorporated with the direct method to calculate the incompressible, conical flow over a slender delta wing at incidence. The location of the secondary separation line on the leeward surface of the wing is determined and compared with experiment for a unit aspect ratio wing at 20.5 deg incidence. The viscous flow in the separated region was calculated using prescribed skin friction coefficients. Author

**N86-27196*#** Notre Dame Univ., Ind.

**AN EXPERIMENTAL INVESTIGATION OF VORTEX BREAKDOWN ON A DELTA WING**

F. M. PAYNE and R. C. NELSON *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 135-161 Jul. 1986
(Contract NAG2-258)
Avail: NTIS HC A18/MF A01 CSCL 01A

An experimental investigation of vortex breakdown on delta wings at high angles is presented. Thin delta wings having sweep angles of 70, 75, 80 and 85 degrees are being studied. Smoke flow visualization and the laser light sheet technique are being used to obtain cross-sectional views of the leading edge vortices as they break down. At low tunnel speeds (as low as 3 m/s) details of the flow, which are usually imperceptible or blurred at higher speeds, can be clearly seen. A combination of lateral and longitudinal cross-sectional views provides information on the three dimensional nature of the vortex structure before, during and after breakdown. Whereas details of the flow are identified in still photographs, the dynamic characteristics of the breakdown process were recorded using high speed movies. Velocity measurements were obtained using a laser Doppler anemometer with the 70 degree delta wing at 30 degrees angle of attack. The measurements show that when breakdown occurs the core flow transforms from a jet-like flow to a wake-like flow. Author

**N86-27197*#** Lockheed-Georgia Co., Marietta.

**LASER VELOCIMETRY IN HIGHLY THREE-DIMENSIONAL AND VORTICAL FLOWS**

C. J. NOVAK, C. R. HUIE, and K. C. CORNELIUS *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 163-185 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

The need for experimentally determined 3-D velocity information is crucial to the understanding of highly 3-dimensional and vortical flow fields. In addition to gaining an understanding of the physics of flow fields, a correlation of velocity data is needed for advanced computational modelling. A double pass method for acquiring 3-D flow field information using a 2-D laser velocimeter (LV) is described. The design and implementation of a 3-D LV with expanded capabilities to acquire real-time 3-D flow field information are also described. Finally, the use of such an instrument in a wind tunnel study of a generic fighter configuration is described. The results of the wind tunnel study highlight the complexities of 3-D flow fields, particularly when the vortex behavior is examined over a range of angles of attack. Author

**N86-27198*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IN-FLIGHT AND WIND TUNNEL LEADING-EDGE VORTEX STUDY ON THE F-106B AIRPLANE**

J. E. LAMAR *In its* Vortex Flow Aerodynamics, Vol. 1 p 187-201 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

The vapor screen technique was successfully applied to an F-106B fighter aircraft during subsonic and transonic maneuvers. This system has allowed the viewing of multiple vortex systems on the wing upper surface at angles of attack less than 19 deg. In addition, similarities as well as differences were determined to exist between the vortex systems for a full scale semispan model and the flight vehicle at 20 deg incidence. Furthermore, variations in Reynolds number and Mach number were identified as to how they affect vortex system details at flight conditions. Author

**N86-27199*#** Vigyan Research Associates, Inc., Hampton, Va.

**BASIC STUDIES ON DELTA WING FLOW MODIFICATIONS BY MEANS OF APEX FENCES**

K. D. HOFFLER, D. M. RAO, and M. C. FRASSINELLI (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio) *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 203-217 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

The effectiveness of apex fences on a 60-deg delta wing at low speeds was experimentally investigated. Resembling highly swept spoilers in appearance, the fences are designed to fold out of the wing apex region upper surface near the leading edges, where they generate a powerful vortex pair. The intense suction of the fence vortices augments lift in the apex region, the resulting positive pitching moment being utilized to trim trailing edge flaps for lift augmentation during approach and landing at relatively low angles of attack. The fences reduce the apex lift at high angles of attack, leading to a desirable nose-down moment. The above projected functions of the apex fence device were validated and quantified through low speed tunnel tests, comprising upper surface pressure surveys on a semispan model and balance measurements on a geometrically similar fully span wing/body configuration. Fence parameters such as area, shape, hinge position and deflection angle were investigated. Typical results are presented indicating the apex fence potential in controlling the longitudinal characteristics of a tail-less delta. Author

**N86-27200*#** Vigyan Research Associates, Inc., Hampton, Va.

**TOWARDS AN ADVANCED VORTEX FLAP SYSTEM: THE CAVITY FLAP**

D. M. RAO *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 219-230 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

An extension of the vortex flap concept was explored with the aim of providing high-alpha flight control capability coupled with maneuver drag reduction for highly swept wing configurations. A retractable lower surface flap mounted on a translating hinge is proposed, allowing chordwise extension as well as deflection, the two movements being independently controlled. The frontal cavity formed by the partially extended and deflected flap captures a vortex above a certain angle of attack. The cavity vortex downwash alleviates the effective incidence of the wing leading edge, thus modulating vortex lift; at the same time, the induced suction in the cavity generates thrust. These postulated aerodynamic features of the cavity flap were validated through low speed tunnel pressure and visualization tests on a 65 deg swept oblique wing model, which also provided initial trends of the leading edge vortex alleviation and cavity suction with respect to flap extension, deflection and angle of attack. Force tests on a 60 deg delta model further showed the cavity flap L/D performance to compare favorably with the conventional vortex flap. A two segment flap arrangement with independently control led segments was envisaged for exploiting the vortex modulation capability of the cavity flap for pitch, roll and yaw control, in addition to drag reduction at high angles of attack. Author

**N86-27201*#** General Dynamics Corp., Fort Worth, Tex.
**VORTEX FLOW HYSTERESIS**
A. M. CUNNINGHAM, JR. *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 231-248 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

An experimental study was conducted to quantify the hysteresis associated with various vortex flow transition points and to determine the effect of planform geometry. The transition points observed consisted of the appearance (or disappearance) of trailing edge vortex burst and the transition to (or from) flat plate or totally separated flows. Flow visualization with smoke injected into the vortices was used to identify the transitions on a series of semi-span models tested in a low speed tunnel. The planforms tested included simple deltas (55 deg to 80 deg sweep), cranked wings with varying tip panel sweep and dihedral, and a straked wing. High speed movies at 1000 frames per second were made of the vortex flow visualization in order to better understand the dynamics of vortex flow, burst and transition. Author

**N86-27202*#** Boeing Military Airplane Development, Seattle, Wash.
**VISCOUS VORTICAL FLOW CALCULATIONS OVER DELTA WINGS**
G. BLOM, J. C. WAI, and H. YOSHIHARA *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 249-261 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

Two approaches to calculate turbulent vortical flows over delta wing configurations are illustrated. The first is for a simple delta wing at low speeds using the boundary layer approximation to treat the effects of the secondary separation. The second is for the supersonic case of a generic fighter using the NASA Ames parabolized Navier/Stokes method. Test/theory comparisons are given in both cases. Author

**N86-27203*#** Lockheed-California Co., Burbank.
**AN EULER AERODYNAMIC METHOD FOR LEADING-EDGE VORTEX FLOW SIMULATION**
P. RAJ and L. N. LONG (Lockheed-Advanced Aeronautics Co., Valencia, Calif.) *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 263-281 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

The current capabilities and the future plans for a three dimensional Euler Aerodynamic Method are described. The basic solution algorithm is based on the finite volume, Runge-Kutta pseudo-time-stepping scheme of FLO-57. Several modifications to improve accuracy and computational efficiency were incorporated and others are being investigated. The computer code is used to analyze a cropped delta wing at 0.6 Mach number and an arrow wing at 0.85 Mach number. Computed aerodynamic parameters are compared with experimental data. In all cases, the configuration is impulsively started and no Kutta condition is applied at sharp edges. The results indicate that with additional development and validation, the present method will be a useful tool for engineering analysis of high speed aircraft. Author

**N86-27205*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**COMPUTATION OF LEADING-EDGE VORTEX FLOWS**
R. W. NEWSOME (Air Force Wright Aeronautical Labs., Hampton, Va.) and J. L. THOMAS *In its* Vortex Flow Aerodynamics, Vol. 1 p 305-330 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

The simulation of the leading edge vortex flow about a series of conical delta wings through solution of the Navier-Stokes and Euler equations is studied. The occurrence, the validity, and the usefulness of separated flow solutions to the Euler equations of particular interest. Central and upwind difference solutions to the governing equations are compared for a series of cross sectional shapes, including both rounded and sharp tip geometries. For the rounded leading edge and the flight condition considered, viscous solutions obtained with either central or upwind difference methods predict the classic structure of vortical flow over a highly swept delta wing. Predicted features include the primary vortex due to leading edge separation and the secondary vortex due to crossflow separation. Central difference solutions to the Euler equations show a marked sensitivity to grid refinement. On a coarse grid, the flow separates due to numerical error and a primary vortex which resembles that of the viscous solution is predicted. In contrast, the upwind difference solutions to the Euler equations predict attached flow even for first-order solutions on coarse grids. On a sufficiently fine grid, both methods agree closely and correctly predict a shock-curvature-induced inviscid separation near the leeward plane of symmetry. Upwind difference solutions to the Navier-Stokes and Euler equations are presented for two sharp leading edge geometries. The viscous solutions are quite similar to the rounded leading edge results with vortices of similar shape and size. The upwind Euler solutions predict attached flow with no separation for both geometries. However, with sufficient grid refinement near the tip or through the use of more accurate spatial differencing, leading edge separation results. Once the leading edge separation is established, the upwind solution agrees with recently published central difference solutions to the Euler equations. Author

**N86-27206*#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**STEADY SUPERSONIC NAVIER-STOKES SOLUTIONS OF A 75 DEG DELTA WING**
T. A. BUTER and D. P. RIZZETTA *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 331-347 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

Steady solutions about a slender sharp edged delta wing in a supersonic freestream for moderate and high angles of attack are obtained numerically by time integration of the unsteady compressible three dimensional laminar Navier-Stokes equations. The main features of the flow, including primary and secondary separation, and vortex position and strength, are adequately simulated in the numerical solutions. Improved resolution of the computational grid in the leading edge region from a previous solution had considerable effect on the accuracy of the solutions. Good agreement between numerical solutions and experimental data was obtained for two cases. A local timestepping procedure is used to speed convergence by approximately a factor of two. Author

**N86-27207*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AN OVERVIEW OF THE FUNDAMENTAL AERODYNAMICS BRANCH'S RESEARCH ACTIVITIES IN WING LEADING-EDGE VORTEX FLOWS AT SUPERSONIC SPEEDS**
D. S. MILLER, R. M. WOOD, and P. F. COVELL *In its* Vortex Flow Aerodynamics, Vol. 1 p 349-377 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

For the past 3 years, a research program pertaining to the study of wing leading edge vortices at supersonic speeds has been conducted in the Fundamental Aerodynamics Branch of the High-Speed Aerodynamics Division at the Langley Research Center. The purpose of the research is to provide an understanding of the factors governing the formation and the control of wing leading-edge vortices and to evaluate the use of these vortices for improving supersonic aerodynamic performance. The studies include both experimental and theoretical investigations and focus primarily on planform, thickness and camber effects for delta wings. An overview of this research activity is presented. Author

**N86-27208*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**WATER TUNNEL RESULTS OF LEADING-EDGE VORTEX FLAP TESTS ON A DELTA WING VEHICLE**
J. H. DELFRATE *In* NASA. Langley Research Center Vortex Flow Aerodynamics, Vol. 1 p 379-389 Jul. 1986
Avail: NTIS HC A18/MF A01 CSCL 01A

A water tunnel flow visualization test on leading edge vortex flaps was conducted at the flow visualization facility of the NASA Ames Research Center's Dryden Flight Research Facility. The

purpose of the test was to visually examine the vortex structures caused by various leading edge vortex flaps on the delta wing of an F-106 model. The vortex flaps tested were designed analytically and empirically at the NASA Langley Research Center. The three flap designs were designated as full-span gothic flap, full-span untapered flap, and part-span flap. The test was conducted at a Reynolds number of 76,000/m (25,000/ft). This low Reynolds number was used because of the 0.076-m/s (0.25-ft/s) test section flow speed necessary for high quality flow visualization. However, this low Reynolds number may have influenced the results. Of the three vortax flaps tested, the part-span flap produced what appeared to be the strongest vortex structure over the flap area. The full-span gothic flap provided the next best performance.
Author

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**N86-27209*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EVALUATION OF 3 NUMERICAL METHODS FOR PROPULSION INTEGRATION STUDIES ON TRANSONIC TRANSPORT CONFIGURATIONS**

S. F. YAROS, J. R. CARLSON, and B. CHANDRASEKARAN (Vigyan Research Associates, Inc., Hampton, Va.) Jun. 1986 23 p Presented at the 4th AIAA Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986
(NASA-TM-87727; NAS 1.15:87727; AIAA-86-1814) Avail: NTIS HC A02/MF A01 CSCL 01A

An effort has been undertaken at the NASA Langley Research Center to assess the capabilities of available computational methods for use in propulsion integration design studies of transonic transport aircraft, particularly of pylon/nacelle combinations which exhibit essentially no interference drag. The three computer codes selected represent state-of-the-art computational methods for analyzing complex configurations at subsonic and transonic flight conditions. These are: EULER, a finitie volume solution of the Euler equation; VSAERO, a panel solution of the Laplace equation; and PPW, a finite difference solution of the small disturbance transonic equations. In general, all three codes have certain capabilities that allow them to be of some value in predicting the flows about transport configurations, but all have limitations. Until more accurate methods are available, careful application and interpretation of the results of these codes are needed. Author

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**N86-27212#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

**ANALYSIS OF WINGS WITH LEADING EDGE AND/OR TRAILING EDGE SEGMENTED (SPANWISE) FLAPS USING PLANAR HORSE SHOE VORTEX LATTICE METHOD**

B. RAJESWARI and H. N. V. DUTT Nov. 1985 74 p
(NAL-TM-AE-8507) Avail: NTIS HC A04/MF A01

A method and a computer program in FORTRAN have been developed for the analysis of wings with segmented leading edge and trailing edge flaps using planar horse-shoe vortices. This computer program can be used to estimate overall aerodynamic characteristics like C sub L, C sub D and C sub M and the detailed local loads for a given wing flap geometry at specified incidence and Mach number. The method has no limitations on aspect ratio, taper ratio and sweep angles. The code has been validated for a number of cases for which experimental data is available. The program is working on UNIVAC 1100-60 computer and takes about 2 minutes to analyze a typical wing-flap configuration (with approximately 120 panels) for a given incidence and Mach number. Author

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**N86-27213*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PRELIMINARY RESULTS OF UNSTEADY BLADE SURFACE PRESSURE MEASUREMENTS FOR THE SR-3 PROPELLER**

L. J. HEIDELBERG and B. J. CLARK 1986 26 p Presented at the 10th Aeroacoustics Conference, Seattle, Wash., 9-11 Jul. 1986
(NASA-TM-87352; E-3106; NAS 1.15:87352; AIAA-86-1893)
Avail: NTIS HC A03/MF A01 CSCL 01A

Unsteady blade surface pressures were measured on an advanced, highly swept propeller known as SR-3. These measurements were obtained because the unsteady aerodynamics of these highly loaded transonic blades is important to noise generation and aeroelastic response. Specifically, the response to periodic angle-of-attack change was measured for both two- and eight-bladed configurations over a range of flight Mach numbers from 0.4 to 0.85. The periodic angle-of-attack change was obtained by placing the propeller axis at angles up to 4 deg to the flow. Most of the results are presented in terms of the unsteady pressure coefficient variation with Mach number. Both cascade and Mach number effects were largest on the suction surface near the leading edge. The results of a three-dimensional Euler code applied in a quasi-steady fashion were compared to measured data at the reduced frequency of 0.1 and showed relatively poor agreement. Pressure waveforms are shown that suggest shock phenomena may play an important part in the unsteady pressure response at some blade locations. Author

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**N86-27217#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

**LA RECHERCHE AEROSPATIALE. BIMONTHLY BULLETIN, NO. 1984-6, NOVEMBER - DECEMBER 1984**

C. SEVESTRE, ed. Paris ESA May 1985 59 p Transl. into ENGLISH of La Recherche Aerospatiale. Bulletin Bimensuel (Paris, France), no. 1984-6, Nov. - Dec. 1984 Original language document was announced in IAA as A84-37528
(ESA-TT-907; ESA-85-95383) Avail: NTIS HC A04/MF A01; HC also available in English and French from ONERA, Paris FF 70

Turbulence models for a separated three dimensional turbulent boundary layer; a vortex point method for calculation of inviscid incompressible flows around rotary wings; effect of Reynolds number on the aerodynamic characteristics of an ogive-cylinder at high angle of attack; a hybrid finite difference-spectral method for computing compressible fluid flows; modeling the dynamic stall of the NACA 0012 profile; and helicopter noise are discussed.

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**N86-27222#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

**DYNAMIC STALL MODELING OF THE NACA 0012 PROFILE**

D. PETOT *In its* La Recherche Aerospatiale. Bimonthly Bulletin, no. 1984-6, November - December 1984 (ESA-TT-907) 4 p May 1985 Previously announced in IAA as A86-12024
Avail: NTIS HC A04/MF A01; HC also available in English and French from ONERA, Paris FF 70

Correlations obtained by ONERA researchers in studies of large amplitude oscillations in airfoils are discussed. The correlation values were generated with a dynamic model for helicopter rotor blades experiencing nonlinear oscillations in the lift/angle of attack or moment/angle of attack hysteresis loops. Comparisons were made between the model predictions and data from NASA experiments with NACA 0012 airfoils at varying angles of attack, amplitudes and frequencies. The model proved adequate for predicting the hysteresis loops and in identifying stall behavior.
M.S.K. (IAA)

**N86-27223#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

**HELICOPTER NOISE**

R. LEGENDRE *In its* La Recherche Aerospatiale. Bimonthly Bulletin, no. 1984-6, November - December 1984 (ESA-TT-907) 3 p May 1985 Previously announced in IAA as A86-12025
Avail: NTIS HC A04/MF A01; HC also available in English and French from ONERA, Paris FF 70

The state of the art in predicting and modeling helicopter noise, its sources, components, magnitudes and dynamic characteristics, is assessed. Noise is not emitted by steady flow, and can be decomposed into noise and pseudo-noise. Account must be taken of pseudo-noise in considerations of passenger comfort. The evolution of vortices in the turbulent boundary layer, the turbulent wake and at the blade tips produces noise. The difficulty in predicting noise arises from the complex behavior of vortices, atmospheric processes which affect the noise during flight and interactions among noise effects of separate blades and the fuselage noise. Various experiments are suggested for deriving quantitative laws to improve noise prediction efforts.
M.S.K. (IAA)

**N86-27224#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics and Flight Mechanics Panel.

**UNSTEADY AERODYNAMICS-FUNDAMENTALS AND APPLICATIONS TO AIRCRAFT DYNAMICS**

Loughton, England Nov. 1985 620 p In ENGLISH and FRENCH Symposium held in Goettingen, West Germany, 6-9 May 1985
(AGARD-CP-386; ISBN-92-835-0382-1) Avail: NTIS HC A99/MF A01

Recent advances in the methods for experimentation and computational prediction of nonlinear flow phenomena in unsteady aerodynamics and of stability parameters required to describe adequately the dynamic behavior of aircraft with special emphasis on high angle-of-attack were examined. Topics addressed include: unsteady boundary layers; unsteady separation and stall; buffeting; unsteady airloads; wind tunnel and flight test techniques, with emphasis on the measurement of nonlinearities, aerodynamic cross-coupling, hysteresis, and time dependent effects; mathematical modeling; bifurcation theory; prediction of wing rock; and advanced control systems.

**N86-27226#** United Technologies Research Center, East Hartford, Conn.

**DYNAMIC STALL OF SWEPT AND UNSWEPT OSCILLATING WINGS**

F. O. CARTA *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 15 p Nov. 1985
Avail: NTIS HC A99/MF A01

Recent unsteady tests on oscillating tunnel-spanning wings (representative of full scale helicopter blades) have shown that the dynamic stall phenomena for a swept wing model is significantly different from that for an unswept wing. Several critical measurements and calculations relative to the behavior of the surface flow were made, including chordwise wave speed of the stalling vortex, the degree of pitch rate dependence of the vortex inception angle, and the ability of the cosine law for sweep to normalize unsteady poststall behavior, even after reattachment occurs. Finally, an examination of hot-film response data shows that the stagnation flow along the swept wing leading edge significantly alters the unsteady surface flow behavior in a narrow region along the leading edge when compared with data from the unswept wing. However, from approximately 15 percent chord and aft there appears to be no sweep effect, and the results from both wings are nearly indistinguishable.
Author

**N86-27228#** Vrije Universiteit, Brussels (Belgium). Dept. of Fluid Mechanics.

**VELOCITY AND TURBULENCE MEASUREMENTS IN DYNAMICALLY STALLED BOUNDARY LAYERS ON AN OSCILLATING AIRFOIL**

J. DERUYCK and C. HIRSCH *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 13 p Nov. 1985 Sponsored in part by Belgian National Research Funds (NFWO)
(Contract DAJA45-83-C-0021)
Avail: NTIS HC A99/MF A01

Detailed velocity and turbulence properties in the dynamically stalled boundary layer of an oscillating NACA 0012 airfoil were measured. The airfoil oscillated around an axis at 25% distance from the leading edge with a sinusoidal motion. Measurements are performed at eight chordwise positions, in non-stalled, stall onset, and deep stalled flow conditions. Instantaneous detailed flow and turbulence patterns of the periodic separation vortex are presented and discussed. Corresponding terms of the turbulent energy balance are derived and compared with flat plate boundary layer data. In particular, negative turbulent energy production is observed during vortex development.
Author

**N86-27229#** Centre National de la Recherche Scientifique, Marseilles (France). Inst. de Mecanique des Fluides.

**WING PROFILE IN STALLED POSITION SUBJECT TO A FLOW OF ALTERNATING POTENTIAL AND STRONG VORTEX [PROFIL D'AILE EN DECROCHAGE SOUMIS A UN ECOULEMENT ALTERNATIVEMENT POTENTIEL ET A FORT VORTICITE]**

C. MARESCA and D. FAVIER *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 15 p Nov. 1985 In FRENCH
Avail: NTIS HC A99/MF A01

The aerodynamic behavior of a wing profile subject to a flow of alternating potential and strong vortex is examined. The simulation experiment consisted of placing a fixed wing profile in the wake of a profile that oscillated at stalling incidence parallel to the flow. The results show that the effects on the fixed profile may be theoretically approximated by considering the profile as isolated in the flow while the amplitude of the speed and the incidence are simultaneously variable with the pre-established values.
Transl. by T. R.

**N86-27230#** Lockheed Missiles and Space Co., Sunnyvale, Calif.

**A CRITICAL LOOK AT DYNAMIC SIMULATION OF VISCOUS FLOW**

L. E. ERICSSON *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics
11 p Nov. 1985
Avail: NTIS HC A99/MF A01

A critical examination is made of the classic role of the wind tunnel as a tool for simulation of the free flight aerodynamics. That the equivalence concept established for steady flow is not valid for unsteady flow is no great surprise. More surprising, probably, is the fact that simulation of the relative velocity time history, which assures simulation of the inviscid unsteady aerodynamics, will in many cases not assure simulation of the unsteady viscous flow. In the case of flow separation and associated hysteresis the lack of simulation of the transient viscous flow can sometimes even generate the incorrect final steady state flow condition. Only close attention to the simulation of the unsteady boundary condition at the vehicle surface can assure the utility of experimental and numerical results for prediction of full scale unsteady viscous flow characteristics.
Author

**N86-27231#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

**UNSTEADY BOUNDARY-LAYER SEPARATION ON AIRFOILS PERFORMING LARGE-AMPLITUDE OSCILLATIONS: DYNAMIC STALL**

W. GEISSLER *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 12 p Nov. 1985
Avail: NTIS HC A99/MF A01

Experimental investigations have exposed a strong dependency of unsteady separation characteristics in the regime of dynamic stall on airfoil shape, Reynolds and Mach number, and frequency and time dependence incidence. A suitable prediction method should be able to account for these various parameters. Coupling procedures between two-dimensional unsteady boundary layers and inviscid surface singularity methods (panel methods) were developed for analytical investigation of unsteady turbulent separation. The influence of various parameters on unsteady separation is discussed in detail and comparison with experimental data is made. The results show that, even for weak coupling between boundary layer and inviscid boundary condition, good correspondence exists between theory and experiment with respect to the development of unsteady separation. Author

**N86-27232*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**COMPUTATIONAL ASPECTS OF UNSTEADY FLOWS**

T. CEBECI (Douglas Aircraft Co., Inc., Long Beach, Calif.), L. W. CARR, A. A. KHATTAB, and S. M. SCHIMKE *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 25 p Nov. 1985
(Contract F496720-82-C-0055)
Avail: NTIS HC A99/MF A01 CSCL 01A

The calculation of unsteady flows and the development of numerical methods for solving unsteady boundary layer equations and their application to the flows around important configurations such as oscillating airfoils are presented. A brief review of recent work is provided with emphasis on the need for numerical methods which can overcome possible problems associated with flow reversal and separation. The zig-zag and characteristic box schemes are described in this context, and when embodied in a method which permits interaction between solutions of inviscid and viscous equations, the characteristic box scheme is shown to avoid the singularity associated with boundary layer equations and prescribed pressure gradient. Calculations were performed for a cylinder started impulsively from rest and oscillating airfoils. The results are presented and discussed. It is conlcuded that turbulence models based on an algebraic specification of eddy viscosity can be adequate, that location of translation is important to the calculation of the location of flow separation and, therefore, to the overall lift of an oscillating airfoil. Author

**N86-27236#** Mykytow (Walter J.), Weymouth, Mass.

**REVIEW OF SMP 1984 SYMPOSIUM ON TRANSONIC UNSTEADY AERODYNAMICS AND ITS AEROELASTIC APPLICATIONS**

W. J. MYKYTOW *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics
45 p Nov. 1985
Avail: NTIS HC A99/MF A01

The latest methods of predicting transonic unsteady airloads for oscillating surfaces and flutter were discussed. Also considered were aerolelastic applications, many of which were made to standard AGARD configurations. The 16 papers and the round table discussion were summarized for coordination with the Fluid Dynamics Panel and the Fluid Mechanics Panel. B.G.

**N86-27237*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**TRANSONIC AERODYNAMIC AND AEROELASTIC CHARACTERISTICS OF A VARIABLE SWEEP WING**

P. M. GOORJIAN, G. P. GURUSWAMY (Informatics, Inc., Palo Alto, Calif.), H. IDE (Rockwell International Corp., Los Angeles, Calif.), and G. MILLER *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 15 p Nov. 1985 Previously announced as N85-25203
Avail: NTIS HC A99/MF A01 CSCL 01A

The flow over the B-1 wing is studied computationally, including the aeroelastic response of the wing. Computed results are compared with results from wind tunnel and flight tests for both low-sweep and high-sweep cases, at 25.0 and 67.5 deg., respectively, for selected transonic Mach numbers. The aerodynamic and aeroelastic computations are made by using the transonic unsteady code ATRAN3S. Steady aerodynamic computations compare well with wind tunnel results for the 25.0 deg sweep case and also for small angles of attack at the 67.5 deg sweep case. The aeroelastic response results show that the wing is stable at the low sweep angle for the calculation at the Mach number at which there is a shock wave. In the higher sweep case, for the higher angle of attack at which oscillations were observed in the flight and wind tunnel tests, the calculations do not show any shock waves. Their absence lends support to the hypothesis that the observed oscillations are due to the presence of leading edge separation vortices and are not due to shock wave motion as was previously proposed. Author

**N86-27238#** National Aerospace Lab., Amsterdam (Netherlands).

**UNSTEADY AIRLOAD COMPUTATIONS FOR AIRFOIL OSCILLATING IN ATTACHED AND SEPARATED COMPRESSIBLE FLOW**

R. HOUWINK *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 8 p Nov. 1985
Avail: NTIS HC A99/MF A01

Recent developments in coupled inviscid flow-boundary layer computations are discussed for airfoils in unsteady motion in attached and separated subsonic and transonic flow. The applicability of quasi-simultaneous strong interaction coupling procedures for transonic small perturbation theory and boundary layer integral methods is illustrated for oscillating airfoils with shock-induced separation. The relevance of the predicted airloads for aeroelastic applications is illustrated using the analysis of an aeroelastic instability of a supercritical wing wind tunnel model. Author

**N86-27239#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

**WIND TUNNEL AND FLIGHT TEST ANALYSIS AND EVALUATION OF THE BUFFET PHENOMENA FOR THE ALPHA JET TRANSONIC WING**

H. BUERS and V. SCHMITT (Office National d'Etudes et de Recherches Aeronautiques, Paris, France) *In* AGARD Unsteady Aerodynamics-Fundamentals and Application to Aircraft Dynamics 11 p Nov. 1985
Avail: NTIS HC A99/MF A01

In addition to previous presentations of wind tunnel and flight test data of the Dornier Transsonischer Tragfluegel (TST) program, results of local flow surveys on the wing in the buffeting region are presented. The vibration levels on the wing and at the pilot's seat are also shown. The separated effects of the slats in use both with and without trailing edge flaps as maneuver flaps up to the transonic flight regime are presented. Author

**N86-27240#** Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).

**UNSTEADY VORTEX AIRFOIL INTERACTION**

G. E. A. MEIER and R. TIMM *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 10 p Nov. 1985

Avail: NTIS HC A99/MF A01

The unsteady flow in the vicinity of an airfoil in a subsonic flow with strong vortices is investigated for a two-dimensional problem. Emphasis was placed on the interaction of the passing vortex flow field with the steady flow field of the airfoil. Unsteady flow separation and generation of new vortices of the airfoil occurs depending on vortex strength and core path. Inviscid calculations of vortex paths and sound generation are compared with the experimental results. The associated pressure waves have a strong directivity. The vortices used for the interaction experiments are generated by different vortex shedding cylinders in a stationary duct flow or by airfoils in the starting flow of a shock-tube. High speed interferometric flow recording and wall pressure measurement are the main experimental techniques. Author

**N86-27241#** Westland Helicopters Ltd., Yeovil (England).

**UNSTEADY AERODYNAMICS APPLICATION TO HELICOPTER NOISE AND VIBRATION SOURCES**

T. S. BEDDOES *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 10 p Nov. 1985

Avail: NTIS HC A99/MF A01

The feasibility of producing aerodynamic loads of sufficient fidelity to enable a realistic acoustic signal to be derived was studied. The need arises from the excessive blade/slap noise which results from blade/vortex interaction. A tool is required to investigate the influence of design and operational parameters as a routine procedure. For this purpose a simplified two dimensional model was developed and validated against a more sophisticated analysis. The model is extended to the rotor application where the complex wake geometry is the determining factor in the character of the loading. From the distributed transient loading an acoustic signal was derived which was compared with experimental data. A comprehensive correlation was not yet performed but the preliminary results are encouraging. Author

**N86-27242*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**RECENT DEVELOPMENTS IN ROTARY-BALANCE TESTING OF FIGHTER AIRCRAFT CONFIGURATIONS AT NASA AMES RESEARCH CENTER**

G. N. MALCOLM and L. B. SCHIFF *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 25 p Nov. 1985 Previously announced as N85-32090

Avail: NTIS HC A99/MF A01 CSCL 01A

Two rotary balance apparatuses were developed for testing airplane models in a coning motion. A large scale apparatus, developed for use in the 12-foot Pressure Wind Tunnel primarily to permit testing at high Reynolds numbers, was recently used to investigate the aerodynamics of 0.05-scale model of the F-15 fighter aircraft. Effects of Reynolds number, spin rate parameter, model attitude, presence of a nose boom, and model/sting mounting angle were investigated. A smaller apparatus, which investigates the aerodynamics of bodies of revolution in a coning motion, was used in the 6-by-6 foot Supersonic Wind Tunnel to investigate the aerodynamic behavior of a simple representation of a modern fighter, the Standard Dynamic Model (SDM). Effects of spin rate parameter and model attitude were investigated. A description of the two rigs and a discussion of some of the results obtained in the respective tests are presented. Author

**N86-27243#** Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept.

**NEW ROTARY RIG AT RAE AND EXPERIMENTS ON HIRM**

C. O. OLEARY and E. N. ROWTHORN *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 14 p Nov. 1985

Avail: NTIS HC A99/MF A01

A rig for measurement of forces and moments due to continuous rate of roll was commissioned at Royal Aircraft Establishment, Bedford. Tests were made on a High Incidence Research Model (HIRM) in two wind tunnels at M = 0.2, 0.4, and 0.7. At present models can be tested up to 40 deg angle of attack at rotational speeds up to 350 rpm. Tests on HIRM included an investigation of configuration and Reynolds number effects. Results are compared with similar data from tests with another rolling rig and from small amplitude oscillatory tests. Author

**N86-27244#** Aeronautical Research Inst. of Sweden, Bromma.

**NEW DYNAMIC TESTING TECHNIQUES AND RELATED RESULTS AT FFA**

T. JANSSON and L. TORNGREN *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 14 p Nov. 1985

Avail: NTIS HC A99/MF A01

Extraction of dynamic derivatives from wind tunnel testing was emphasized in recent years. This is shown from the number of different rigs developed and in use, both in the subsonic and transonic wind tunnels. Brief descriptions of the different rigs, testing procedures and data handling were given. A wide survey of the different rigs used for dynamic derivative testing and the corresponding testing capability are presented. B.G.

**N86-27245#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

**STANDARD DYNAMICS MODEL EXPERIMENTS WITH THE DFVLR/AVA TRANSONIC DERIVATIVE BALANCE**

E. SCHMIDT *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 16 p Nov. 1985

Avail: NTIS HC A99/MF A01

A slender high-load forced-oscillation measuring system for dynamic derivatives of aircraft and missile models in a transonic wind tunnel is presented together with typical test results of the significant aerodynamic coefficients and stability derivatives of the Standard Dynamics Model, a simplified fighter aircraft model with a wing span of 0.345 m. The measurements in the rotational modes pitch, yaw, and roll encompass Mach numbers from 0.6 to 1.2, angles of attack from 0 to 30 degrees, and excitation frequencies from 2 to 20 Hz at a constant Reynolds number of 7.8 Mio/m. Most of the stiffness and damping derivatives gathered show substantial nonlinear dependence on Mach number and angle of attack, whereas the influence of reduced frequency is less prominent. The results are closely related to published measurements on Standard Dynamic Models performed in other NATO countries. Author

**N86-27246#** Institut de Mecanique des Fluides de Lille (France).

**RECENT DEVELOPMENTS IN TECHNIQUES FOR DYNAMIC SIMULATION FOR THE IDENTIFICATION OF STABILITY PARAMETERS [RECENTS DEVELOPPEMENTS DES TECHNIQUES DE SIMULATION DYNAMIQUE APPLIQUEES A L'IDENTIFICATION DES PARAMETRES DE STABILITE]**

D. TRISTRANT and O. RENIER *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 14 p Nov. 1985 In FRENCH

Avail: NTIS HC A99/MF A01

In the aircraft dynamic behavior prediction context, experimental methods and analytical procedures which allow mathematical linear modeling parameters to be identified, using a test apparatus located at the Institut de Mecanique des Fluides de Lille is presented. The rig characteristics, the experimental procedures, the identification methods, and results from different aircraft models will be described. Emphasis is put on the interest of a specifc lambda degree of freedom angle formed by the rotational vector and velocity vector. Effectively, it is shown that rotational tests with a non zero value of lambda offer interesting possibilities for identification and allow the estimation of linear model parameters in the case of a quasi-linear path. A different degree of freedom, called gyration radius, was obtained by fixing a special mechanism onto the test apparatus. By carrying out a carefully selected test program, this degree of freedom allows the whole set of stability parameters to be identified, given the structure of the linear mathematical model. Finally, dynamic measures obtained during oscillatory coning using a complete aircraft model produced in evidence the large amplitude of unsteady aerodynamic phenomena at high angles of attack, which could not be ignored if prediction of post stall evolutions is sought. Author

**N86-27247#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). . Inst. fuer Flugmechanik.

### GENERATION OF TWO-DIMENSIONAL GUST FIELDS IN SUBSONIC WIND-TUNNELS

B. KRAG and W. WEGNER (Technische Univ., Brunswick, West Germany) *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 12 p Nov. 1985
Avail: NTIS HC A99/MF A01

For a variety of flight vehicles, problems during flight in turbulence at subsonic speeds are expected: mainly slow flying helicopters, tilt rotorcraft, aircraft maneuvering at high angles of attack, wing in ground effect vehicles, and aircraft with active controlled wings. The investigation of these problems posses large difficulties. The analyst rapidly enters domains where computational methods fail and where wind tunnel experiments are necessary. This raises the problem of stimulating atmospheric turbulence in a wind tunnel. Until now, no fundamental investigations of the problem of gust generation in wind tunnels were undertaken. Investigations of gust generations were started in a model subsonic wind tunnel. In order to recognize the influence of the main parameters, like number of lift generating wings, chord length, trailing edge-flap or jet-flap, constant chord wing or side-wall mounted winglets, four different types of gust generators were investigated. The gust field was harmonically oscillating. Frequency response measurements of the gust angle of attack were made, covering the complete volume of the test section. Additionally the flow field in the wind tunnel behind harmonically oscillating gust generator flaps was calculated. The results were compared with the measurements. Author

**N86-27248*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

### EXTRACTION OF AERODYNAMIC PARAMETERS FOR AIRCRAFT AT EXTREME FLIGHT CONDITIONS

K. W. ILIFF *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 21 p Nov. 1985
Avail: NTIS HC A99/MF A01 CSCL 01A

The maximum likelihood estimator was used to extract stability and control derivatives from flight data for many years. Most of the literature on aircraft estimation concentrates on new development and applications, assuming familiarity with basic concepts. The maximum likelihood estimator and the aircraft equations of motion that the estimator uses are discussed. The current strength and limitations associated with obtaining flight-determined aerodynamic coefficients in extreme flight conditions are assessed. The importance of the careful combining of wind tunnel results (or calculations) and flight results and the thorough evaluation of the mathematical model is emphasized. The basic concepts of minimization and estimation are examined for a simple computed aircraft example, and the cost functions that are to be minimized during estimation are defined and discussed. Graphic representations of the cost functions are given to help illustrate the minimization process. Finally, the basic concepts are generalized, and estimation of stability and control derivatives from flight data is discussed. Author

**N86-27249*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### NONLINEAR PROBLEMS IN FLIGHT DYNAMICS INVOLVING AERODYNAMIC BIFURCATIONS

M. TOBAK and G. T. CHAPMAN *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 15 p Nov. 1985 Previously announced as N85-25206
Avail: NTIS HC A99/MF A01 CSCL 01A

Aerodynamic bifurcation is defined as the replacement of an unstable equilibrium flow by a new stable equilibrium flow at a critical value of a parameter. A mathematical model of the aerodynamic contribution to the aircraft's equations of motion is amended to accommodate aerodynamic bifurcations. Important bifurcations such as, the onset of large-scale vortex shedding are defined. The amended mathematical model is capable of incorporating various forms of aerodynamic responses, including those associated with dynamic stall of airfoils. E.A.K.

**N86-27250*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### BIFURCATION THEORY APPLIED TO AIRCRAFT MOTIONS

W. H. HUI (Waterloo Univ., Ontario) and M. TOBAK *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 14 p Nov. 1985 Previously announced as N85-23705
Avail: NTIS HC A99/MF A01 CSCL 01A

The bifurcation theory is used to analyze the nonlinear dynamic stability characteristics of single-degree-of-freedom motions of an aircraft or a flap about a trim position. The bifurcation theory analysis reveals that when the bifurcation parameter, e.g., the angle of attack, is increased beyond a critical value at which the aerodynamic damping vanishes, a new solution representing finite-amplitude periodic motion bifurcates from the previously stable steady motion. The sign of a simple criterion, cast in terms of aerodynamic properties, determines whether the bifurcating solution is stable (supercritical) or unstable (critical). For the pitching motion of a flap-plate airfoil flying at supersonic/hypersonic speed, and for oscillation of a flap at transonic speed, the bifurcation is subcritical, implying either that exchanges of stability between steady and periodic motion are accompanied by hysteresis phenomena, or that potentially large aperiodic departures from steady motion may develop. On the other hand, for the rolling oscillation of a slender delta wing in subsonic flight (wing rock), the bifurcation is found to be supercritical. This and the predicted amplitude of the bifurcation periodic motion are in good agreement with the experiments. Author

**N86-27251#** National Research Council of Canada, Ottawa (Ontario).

### DYNAMIC NONLINEAR AIRLOADS: REPRESENTATION AND MEASUREMENT

E. S. HANFF *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 14 p Nov. 1985
Avail: NTIS HC A99/MF A01

A new representation of aerodynamic reactions (in terms of the motion variables), which does not rely on assumptions of linearity, is proposed. This representation is, therefore, indicated for extreme flight conditions where a locally linearized model is usually of questionable value. The significance within the present context of stability derivatives is discussed with the intention of pointing out their range of applicability. A wind tunnel technique, capable of efficiently obtaining the bulk of the data required for the effective use of the representation is briefly described. Author

**N86-27252*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**RECENT EXPERIENCES OF UNSTEADY AERODYNAMIC EFFECTS ON AIRCRAFT FLIGHT DYNAMICS AT HIGH ANGLE OF ATTACK**
L. T. NGUYEN, R. D. WHIPPLE, and J. M. BRANDON *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 25 p Nov. 1985
Avail: NTIS HC A99/MF A01

Recent research is highlighted which was conducted at the NASA Langley Research Center on two high angle-of-attack flight dynamic phenomena which are dominated by unsteady aerodynamic effects: wing rock and tumbling. Studies of wing rock induced by strong vortical flows and tumbling characteristics observed on an advanced configuration are reviewed. Results of wind tunnel experiments are summarized and the aerodynamic mechanisms involved in the phenomena were discussed. Author

**N86-27253#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Avionics Lab.
**UNSTEADY AERODYNAMICS AND DYNAMIC AIRCRAFT MANEUVERABILITY**
J. D. LANG and M. S. FRANCIS (Air Force Space Div., Los Angeles, Calif.) *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 19 p Nov. 1985
Avail: NTIS HC A99/MF A01

A forecast of future aerial combat predicated on anticipated technological advances and weapons developments suggests a need for supermaneuverable aircraft possessing greatly enhanced turning and virtually instantaneous point-and-shoot capabilities. The potential advantage of exploiting this unique flight environment was discussed along with a detailed description of expected vehicle dynamic behavior. An emerging picture of the unsteady aerodynamic behavior which will be experienced during these violent maneuvers dictates a need for greater vehicle and flow field control capabilities far in excess of any previously employed in application. However, the successful implementation of advanced control techniques may well beneficially exploit the unusual flow phenomena associated with this nonclassical method of flight. The research discoveries and developmental ideas generated during the next decade will likely alter the concept of maneuvering flight as it is known and lead to a new generation of aircraft with vastly improved combat capabilities. Author

**N86-27254#** London Univ. (England). Dept. of Aeronautical Engineering.
**ON THE INTERFACE BETWEEN UNSTEADY AERODYNAMICS, DYNAMICS AND CONTROL**
G. J. HANCOCK and R. VEPA *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 12 p Nov. 1985
Avail: NTIS HC A99/MF A01

The problems of interfacing the mathematical representation of linearized unsteady aerodynamics with dynamic response such that the eigenvalue of the dynamic response are correctly obtained. These eigenvalues are then used in control synthesis. Particular attention is paid to C sub M2 (lag effect between the main wing and tail) in the context of aircraft dynamics. The concept of quasi-steady aerodynamics is clarified. Author

**N86-27255#** Royal Aircraft Establishment, Farnborough (England).
**CORRELATION OF PREDICTED AND FREE-FLIGHT RESPONSES NEAR DEPARTURE CONDITIONS OF A HIGH INCIDENCE RESEARCH MODEL**
A. J. ROSS and G. F. EDWARDS *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 13 p Nov. 1985
Avail: NTIS HC A99/MF A01

The mathematical model of aerodynamic forces and moments is described, based on results from various wind tunnel experiments with the Royal Airforce Establishment High Incidence Research Model (HIRM). Simulations of the responses due to longitudinal and lateral control inputs at high angles of attack are compared with the responses measured on free-flight models of the configuration. The main features of the flight behavior are reproduced, in particular such phenomena as roll-off, wing rock, and nose slice. Author

**N86-27256#** Kansas Univ., Lawrence. Dept. of Aerospace Engineering.
**THEORETICAL PREDICTION OF WING ROCKING**
C. E. LAN *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 13 p Nov. 1985
Avail: NTIS HC A99/MF A01

Wing rock is primarily a rolling oscillation about the longitudinal body axis at high angles of attack. It involves nonlinear interaction between flight dynamics and aerodynamics. A nonlinear aerodynamic model was proposed earlier to predict the wing rock frequency and amplitude of low aspect-ratio configurations with good accuracy. The theory is applied to a twin-jet fighter aircraft of moderate aspect ratio and to a low-speed configuration of high aspect ratio. For the purpose of predicting necessary aerodynamic derivatives, a lifting surface method coupled with nonlinear airfoil section data is developed. The results show that wing rock can be predicted with the present wing-rock and aerodynamic theories. It is also found that for configurations of high aspect ratio, the one degree of freedom dynamic model in the present wing rock theory should be used. For other configurations, the three degrees of freedom model is more appropriate. Author

**N86-27257#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
**EFFECTS OF AERODYNAMIC LAGS ON AIRCRAFT RESPONSES**
J. C. VANDERVAART *IN* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 11 p Nov. 1985
Avail: NTIS HC A99/MF A01

Results of a theoretical study on the effects of unsteady aerodynamics on symmetric aircraft responses due to elevator and vertical turbulence imputs, are presented. Several linear models were developed to describe unsteady lift and downwash and delays due to horizontal tail length. Results for three example aircraft types show that calculated normal acceleration levels due to turbulence are very little affected by including unsteady wing lift and downwash. However, there appears to be a noticeable influence on plunging acceleration and pitch rate response to elevator or vertical turbulence inputs. Author

**N86-27258#** Smith Associates Consulting System Engineers Ltd., Cobham (England).
**A SELF-ORGANISING CONTROL SYSTEM FOR NON-LINEAR AIRCRAFT DYNAMICS**
C. EVANS *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 12 p Nov. 1985
Avail: NTIS HC A99/MF A01

At high angles of attack (AOA) flow separations can produce nonlinear and time varying aerodynamic loads, which cannot be predicted with great certainty. Such loads make control system development extremely difficult. A control system was developed which can accomplish on-line reduction of the a priori uncertainties pertaining to the effective control of the aircraft. The self-organizing control system was developed to suppress unacceptable pitch-up tendencies of an aircraft at high AOA, without the use of AOA measurement. The final control system demonstrated good performance for a variety of inputs although performance was not as good in turbulence. Author

**N86-27259#** Messerschmitt-Boelkow G.m.b.H., Munich (West Germany). Hubschrauber und Flugzeuge.

**GUST ALLEVIATION ON A TRANSPORT AIRPLANE**

J. BECKER, F. WEISS, E. CAVATORTA (Aeritalia S.p.A., Naples, Italy), and C. CALDARELLI *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 9 p Nov. 1985

Avail: NTIS HC A99/MF A01

A Gust Alleviation System on a preliminary configuration of a commuter aircraft was analyzed. The analysis takes into account the influence of the elasticity of the aircraft, unsteady aerodynamic effect, and mechanical nonlinearities such as backlash-deadzone, control surface rate, and deflection limitations. A relatively simple model shows that ride comfort can be improved by at least 50%. Author

**N86-27261*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**UNSTEADY INTERACTIONS OF TRANSONIC AIRFOILS WITH GUSTS AND CONCENTRATED VORTICES**

W. J. MCCROSKEY and G. R. SRINIVASAN (JAI Associates, Mountain View, Calif.) *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 13 p Nov. 1985

Avail: NTIS HC A99/MF A01

Unsteady interactions of strong concentrated vortices, distributed gusts, and sharp-edged gusts with stationary airfoils were analyzed in two-dimensional transonic flow. A simple and efficient method for introducing such vortical disturbances was implemented in numerical codes that range from inviscid, transonic small-disturbance to thin-layer Navier Stokes. The numerical results demonstrate the large distortions in the overall flow field and in the surface air loads that are produced by various vortical interactions. The results of the different codes are in excellent qualitative agreement, but, as might be expected, the transonic small-disturbance calculations are deficient in the important region near the leading edge. Author

**N86-27262#** Hellenic Air Force Technology Research Center, Athens (Greece).

**MODELLING OF THE VORTEX-AIRFOIL INTERACTION**

A. G. PANARAS *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 16 p Nov. 1985

Avail: NTIS HC A99/MF A01

A modeling of the vortex-airfoil interaction is presented in which the finite-area of the real vortices is taken into consideration. Two vortex models are used. In the first, a disturbed piece of vorticity layer is simulated by four rows of discrete vortices of small strength. In the second, a number of discrete vortices is arranged within a circle. The first model may simulate a shear layer or a wake, while the second, a well-formed vortex. The method was applied to the calculation of the pressure induced on the surface of the airfoil by the interacting vortex. Both models give similar results. It was found that for large distances of the vortex from the surface of the airfoil, the consideration or not of the finite-area of the vortex is not a significant factor in determining the induced pressure field. However, when the distance of the vortex from the surface is reduced, its shape is distorted and the induced pressure pulses have lower amplitude than the ones induced by an equivalent point vortex. In the limit, where the vortex impinges on the leading edge of the airfoil, it is split into two and the time dependent pressure coefficient takes even negative values at some time intervals. Author

**N86-27263#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

**IDENTIFICATION OF AIRCRAFT CHARACTERISTICS INCLUDING GUST INDUCED DYNAMIC EFFECTS**

D. ROHLF *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 8 p Nov. 1985

Avail: NTIS HC A99/MF A01

For the investigation of unsteady aerodynamic effects at low Mach numbers, dynamic tests using controllable models of a light transport aircraft were performed in wind tunnels in the Dynamic Simulation Facility (Germany) and the Free Flight Catapult Facility (France). These model test techniques have the advantage of laboratory conditions with the possibility of generating reproducible qusts. The achieved flight test data were analyzed in detail applying method of system identification. This included the determination of the discrete gust disturbance from onboard measured signals. An approach was presented which used the measured angle of attack and additional calculated dynamic terms, which become essential in the presence of fast flow changes due to short-wave gusts or high-frequency control deflection. Measured time histories of model flight tests with excitation by control inputs and gusts are presented and compared with identification results obtained from the multi-run evaluation. Author

**N86-27264#** Sherbrooke Univ. (Quebec). Dept. de Genie Mecanique.

**EXPERIMENTAL STUDY OF THE EFFECT OF TURBULENCE ON DYNAMIC STALLING [ETUDE EXPERIMENTALE DE L'EFFET DE LA TURBULENCE SUR LE DECROCHAGE DYNAMIQUE]**

A. LANEVILLE, P. VITTECOQ, and J. COTE *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 7 p Nov. 1985 In FRENCH

Avail: NTIS HC A99/MF A01

The results of a study of dynamic stalling for different intensities of turbulence in the flow of a wind tunnel are presented. The test was conducted on a NACA 0018 profile with sinusoidal oscillation. The results show that turbulence modifies both static and dynamic stall phenomena. It is shown that turbulence stabilizes the boundary layer at the leading edge, while allowing the profile to attain larger angles of incidence before stalling. In addition, turbulence alters the formation of vortices at the leading edge. Transl. by T. R.

**N86-27265*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**APPLICATION OF CFD TECHNIQUES TOWARD THE VALIDATION OF NONLINEAR AERODYNAMIC MODELS**

L. B. SCHIFF and J. KATZ *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics 15 p Nov. 1985 Previously announced as N85-26671

Avail: NTIS HC A99/MF A01 CSCL 14B

Applications of computational fluid dynamics (CFD) methods to determine the regimes of applicability of nonlinear models describing the unsteady aerodynamic responses to aircraft flight motions are described. The potential advantages of computational methods over experimental methods are discussed and the concepts underlying mathematical modeling are reviewed. The economic and conceptual advantages of the modeling procedure over coupled, simultaneous solutions of the gas dynamic equations and the vehicle's kinematic equations of motion are discussed. The modeling approach, when valid, eliminates the need for costly repetitive computation of flow field solutions. For the test cases considered, the aerodynamic modeling approach is shown to be valid. Author

**N86-27266#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
**STUDY OF THE TRANSITION BEHAVIOR OF AN AIRPLANE IN THE VICINITY OF BIFURCATION POINTS [ETUDE DU COMPORTEMENT TRANSITOIRE D'UN AVION AU VOISINAGE DE POINTS DE BIFURCATION]**
P. GUICHETEAU *In* AGARD Unsteady Aerodynamics-Fundamentals and Applications to Aircraft Dynamics
7 p Nov. 1985 In FRENCH
Avail: NTIS HC A99/MF A01

The transition behavior of an aircraft in the vicinity of bifurcation points, using a differential system method to analytically determine nonlinearities is discussed. The method proposed does not require the reduction of the differential system. Primary applications for this method include studies on fighter aircraft. Transl. by T. R.

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-37327**
**THE RISK TO THIRD PARTY PERSONNEL FROM RPV OPERATIONS**
V. COHEN (Theta Analysis and Systems, Ltd., Aldershot, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 3.1-3.7.

An evaluation is made of the risk that RPV battlefield operations present for ground personnel. Statistical material has been drawn from accident records for manned aircraft in the UK representing 11,600 accidents of relevant type, including 55 cases of third-party injury. Attention was given to possible correlations between injury rate and such variables as the aircraft wingspan and the weight/speed of aircraft. Considerable expense is projected for an RPV system complying with the required reliability levels. O.C.

**A86-37469**
**AN AVIATION COMPOSITE HAZARDS PRODUCT**
W. D. ZITTEL (NOAA, National Weather Service, Norman, OK) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 109-116. refs

The progress made by the Interim Operational Test Facility Staff between April and July 1984 in the founding of an aviation composite hazards product for the Next Generation Weather Radar (NEXRAD) is summarized. In designing this product, such hazards as heavy rain, gust fronts, turbulence, wind shear and tornadoes were considered injurious to aviation. Line contours were established for each hazard which were subsequently described functionally. The identity of each hazard was maintained and the contours were sufficiently grated to maintain time and space continuity. Hazards having areal extent were functionally described using harmonic analysis. Areas discussed in detail include NEXRAD algorithms, the mathematical methodology, display construction and future work. The results attest to the feasibility of functionally contouring hazards for use in an aviation composite hazards product. K.K.

**A86-37477**
**THE HAZARDS OF ASH CLOUDS TO CIVIL AIR TRANSPORT**
MR. REDDAN (Air France, Roissy, France) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 146, 147.

The hazard posed to commercial aviation by ash clouds from erupting volcanoes is discussed. The capability of cloud matter to cause engine failure, to erode windshields, leading edges, fan blades, aerials, and landing lights, and to choke filters and pipes is described. Radar and satellite methods of detecting ash clouds are addressed, and the importance of further measures is stressed, particularly the need for a network to gather and distribute information. C.D.

**A86-37478**
**METEOSAT-DERIVED QUANTITATIVE MEASUREMENTS ON VOLCANIC ASH PLUMES FOR WARNING TO AVIATION**
B. BIZZARRI, P. PAGANO, and M. PERRONE (Aeronautica Militare Italiana, Servizio Meteorologico, Rome, Italy) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 148-151. refs

The use of the Meteosat satellite to detect and evaluate plumes of volcanic ash which pose a danger to aviation is discussed. A Meteosat infrared image of a plume is shown and discussed, and the image is used to derive quantitative information on the plume's height, emissivity, optical thickness, eruption energy, ash mass, mass evolution and abatement, and vertical distribution and concentration. The verification of these analytical results and the evaluation of the risk posed by this plume are briefly discussed. A possible procedure for warning aircraft is considered. C.D.

**A86-37479*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**NASA STORM HAZARDS RESEARCH IN LIGHTNING STRIKES TO AIRCRAFT**
B. D. FISHER, P. W. BROWN (NASA, Langley Research Center, Hampton, VA), and J. A. PLUMER (Lightning Technologies, Inc., Pittsfield, MA) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 152-160. refs

The lightning strike condition data gathered in the 1980-1984 period are presented, together with the lightning attachment point analysis for the NASA F-106B research aircraft are presented. The analysis of the experienced 637 direct lightning strikes shows that the highest strike rates (2.1 strikes/min and 13 strikes/penetration) occurred at altitudes between 38,000 and 40,000 ft. The regions of highest risk for an aircraft to experience a direct lightning strike were the areas of thunderstorms where the ambient temperature was colder than -40 C and where the relative turbulence and precipitation intensities were characterized as negligible to light. The presence and location of lightning, therefore, did not necessarily indicate the presence and location of hazardous precipitation and turbulence. The total onboard data show that the lightning attachment patterns on this aircraft fall into four general categories, although the 1984 data suggest that the entire surface of the F-106B may be susceptible to lightning attachment. I.S.

**A86-37482**
**TERRAIN-INDUCED WIND SHEAR - POTENTIAL CAUSE OF JETSTAR ACCIDENT**
W. FROST (Tennessee, University, Tullahoma), J. MCCARTHY, P. HILDEBRAND (National Center for Atmospheric Research, Boulder, CO), and K. H. HUANG (FWG Associates, Inc., Tullahoma, TN) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 177-185. Research supported by the U.S. Department of Justice and NSF. refs

An investigation was made to ascertain the effects of terrain-induced wind shear on the Jetstar accident near Westchester County Airport, in White Plains, New York on February 11, 1981. A mathematical model of the quasi-steady winds experienced by the airplane was developed, with computer-simulated turbulence fluctuations superimposed. The approach path of the aircraft through these winds was computed using a six-degree-of-freedom, aircraft dynamics computer program. These models were collaborated by simulating the flow field in an atmospheric boundary layer simulation water tunnel. The mathematical model of the wind field exhibited excellent agreement with these water tunnel simulations, and it is concluded that the model presented is a realistic simulation of the wind shear effects that may have influenced the accident. Moreover, the results illustrate that terrain features along airport approach paths can produce augmented low-level turbulence together with hazardous wind shear. K. K.

**A86-37489**

### THE CRASH OF C-GTLA - THE CUMULATIVE EFFECTS OF SMALL DEFECTS AND A HINT OF A PREVIOUSLY UNRECOGNIZED MAJOR METEOROLOGICAL HAZARD

W. F. ZELTMANN (International Weather Corp., Brooklyn, NY) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 218, 219.

The November 1983 crash of the C-CGTLA aircraft in the vicinity of the Lansdowne House weather station in Northern Ontario is investigated. A severe winter storm was centered over Wisconsin and moving northward; heavy snow was falling in the vicinity of Lansdowne House on a steady flow of northeasterly winds off Hudson Bay and James Bay. The whiteout conditions experienced by the pilot may have been enhanced by a microburst within instability snow showers. It is noted that a combination of a microburst and a whiteout is extremely hazardous, and a serious effort must be made to determine how often these two phenomena occur together. It is suggested that past accident reports by canvassed to determine their mutual frequency, and that an airport on the shores of the Great Lakes be instrumented to obtain statistical data. K.K.

**A86-37490**

### LIGHTNING MEASUREMENTS OF AN AIRCRAFT FLYING AT LOW ALTITUDE

P. L. RUSTAN, JR. and J. L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 220-225. refs

In a combined USAF/FAA inflight lightning-measurements program, an instrumented FAA CV-580 aircraft flew in and near active thunderstorms in Florida; data were collected on 21 direct lightning strikes to the aircraft. The primary purpose of this program was to characterize the lightning waveform so that the electromagnetic hazards to aircraft due to lightning strikes could be determined. Meteorological conditions conducive to lightning strikes were investigated, and these CV-580 statistics were compared to those obtained by other research aircraft as well as commercial and military aircraft. The CV-580 experienced 63 percent of its strikes at an altitude of 18,000 ft, at which point the aircraft was closer to the large negative charge center of the thunderstorm and more likely to trigger an intracloud discharge. The characteristics of this discharge are also a function of altitude. K.K.

**A86-37625**

### MICROCOMPUTERS AND AVIATION

P. GARRISON New York, Wiley Press, 1985, 279 p.

The different ways in which microcomputers can be useful to pilots and others involved in different phases of aviation are discussed. The Flight Simulator II software aviation package, which turns a microcomputer into a fully-equipped stationary single-engine aircraft which can take off, fly, and land is examined. A variety of commercially marketed software packages that can be used by pilots for flight planning and instrument training are described. A library of aviation programs is presented which can be keyed into a microcomputer to perform a variety of tasks, such as determining weight-and-balance conditions, finding takeoff distances under different wind, weather, and runway conditions and the determining the best cruising altitude based on winds aloft. C.D.

**A86-37940**

### PUTTING A PRICE ON SAFETY

R. ASHFORD (Civil Aviation Authority, London, England) Flight International (ISSN 0015-3710), vol. 129, April 19, 1986, p. 39-42.

The differences between the US Federal Airworthiness Regulations (FAR 25) and the European Joint Airworthiness Requirements (JAR 25) are elucidated, and the demands by aircraft manufacturing and operating industries for greater uniformity of international standards are investigated. It is proposed that the aviation industry should insist on both the deletion of these differences, and their resolution. Moreover, no regulation should be allowed where the savings do not exceed the cost; in US safety terms, savings are expressed in terms of lives saved (valued at $650,000 per life in 1983) and the material losses avoided. Examples are provided of aircraft components which have taken these factors into account. The value of airworthiness directives is demonstrated in light of the British Airtours Boeing 737 accident in August, 1985, and it is recommended that authorities be totally independent of their country's manufacturers, operators and accident investigators. It is concluded that air safety regulation is essential; without it, the airlines would be in an even more competitive position. K.K.

**A86-38343**

### HUMAN INJURY CRITERIA RELATIVE TO CIVIL AIRCRAFT SEAT AND RESTRAINT SYSTEMS

R. F. CHANDLER (FAA, Civil Aeromedical Institute, Oklahoma City, OK) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p. refs

(SAE PAPER 851847)

The use of injury criteria as a basis for the acceptance of seats and restraint systems designed to possess some capacity for crash injury protection has been common for several years in military aircraft and automotive systems, but has only recently been considered for civil aircraft systems. This paper will present the background for the concept of 'injury criteria' as distinct from 'voluntary human tolerance', and will explain methods used in developing certain criteria which are most likely to be useful in evaluating civil aircraft seat and restraint system performance. Finally, techniques for using the measurements in testing will be summarized, and guidance will be provided to the system designer which may assist in meeting the goals established by the criteria. Author

**A86-38344**

### UPPER TORSO RESTRAINT SYSTEMS

E. L. JAERGER (Cessna Aircraft Co., Wichita, KS), H. W. SMITH (Kansas, University, Livermore), and R. F. CHANDLER (FAA, Protection and Survival Laboratory, Oklahoma City, OK) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p.

(SAE PAPER 851848)

A new SAE Aerospace Standard has been developed for upper torso restraint systems in anticipation of mandatory installation in 1986. Shoulder harness integration with pelvic restraint belts are described. Load and performance tests of complete assemblies are described. Details of the system include webbing, seat anchors, buckles, buckle mating plates, adjusters, and emergency locking retractors. Minimum performance requirements and tests for each component are prescribed in the new standard. Tests include effect of flame, light solvents, and abrasion of the webbing. The hardware must qualify for corrosion, temperature and durability. Entire assemblies must be tested to prescribed pelvic and harness loads. These tests are described. Author

**A86-38351**

### CONTROLLED IMPACT DEMONSTRATION REVIEW

N. A. BLAKE (FAA, Washington, DC) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 6 p.

(SAE PAPER 851884)

Data from the controlled impact demonstration conducted on December 1, 1984 by the FAA and NASA are analyzed. The effectiveness of the antimisting fuel additives, seats and restraint systems, and the cabin fire safety materials was evaluated and crashworthiness/crash behavior data was collected. The proposed and actual aircraft impact profiles are described. The test data reveal that the cabin conditions remained habitable, all emergency exits were operable, and the seat fire blocking layers and restraint systems were effective; however, it is observed that under certain conditions the antimisting fuel is not sufficient to prevent a post-crash fire. The crashworthiness data are applied to computer modeling programs for predicting impact forces and crash behavior, and to crash dynamics structural research. I.F.

**A86-38352*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**NASA EXPERIMENTS ONBOARD THE CONTROLLED IMPACT DEMONSTRATION**

R. J. HAYDUK, E. ALFARO-BOU (NASA, Langley Research Center, Hampton, VA), and E. L. FASANELLA (PRC Kentron, Inc., Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 13 p.
(SAE PAPER 851885)

The structural crashworthiness tests conducted by NASA on the December 1, 1984 controlled impact demonstration are discussed. The components and locations of the data acquisition and photographic systems developed by NASA to evaluate impact loads throughout the aircraft structure and the transmission of loads into the dummies are described. The effectiveness of the NASA designed absorbing seats and the vertical, longitudinal, and transverse impact loads are measured. Data that is extremely applicable to crash dynamics structural research was obtained by the data acquisition system and very low load levels were measured for the NASA energy absorbing seats. I.F.

**A86-38353**

**ANTIMISTING FUEL TECHNOLOGY FOR TRANSPORT CATEGORY AIRCRAFT**

E. P. KLUEG (FAA, Washington, DC) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 17 p. refs
(SAE PAPER 851886)

The Federal Aviation Administration has been engaged in research and development efforts aimed at reducing the fire hazard during impact-survivable aircraft crashes by modifying kerosene jet fuels. Primary emphasis has been placed on utilizing high molecular weight, polymeric additives to produce antimisting kerosene fuels which are compatible with commercial transport aircraft and engine fuel systems and are more resistant to vaporization, ignition, and flame propagation in the crash situation. The program background is reviewed, and recently-completed research and development efforts are discussed. Topics covered include the rheological, physical, and flammability properties; the airport production techniques; and aircraft fuel system compatibility characteristics of antimisting kerosene fuel. The results of the full-scale validation phase of the program are also discussed, including aircraft ground and flight tests and a full-scale transport aircraft impact demonstration. Author

**A86-38354**

**FAA STRUCTURAL CRASH DYNAMICS PROGRAM UPDATE - TRANSPORT CATEGORY AIRCRAFT**

S. SOLTIS, C. CAIAFA (FAA, Washington, DC), and G. WITTLIN (Lockheed-California Co., Burbank, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 19 p. refs
(SAE PAPER 851887)

The objectives and initial findings of the FAA-sponsored structural crash dynamics research are described. Results from the fuselage drop tests, full scale aircraft drop tests, and the Controlled Impact Demonstration are presented. A computer modeling program for improved transport aircraft crash dynamics, correlated with the test data, is being developed. A seat/occupant model representative of transport category aircraft seats has been developed. I.S.

**A86-38381**

**THE F-16 AIRCRAFT AND HYDRAZINE - AN INDUSTRIAL HYGIENE PERSPECTIVE**

W. D. CHRISTENSEN (USAF, Occupational and Environmental Health Laboratory, Brooks AFB, TX) and J. A. MARTONE (USAF, Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p. refs
(SAE PAPER 851971)

The USAF program for controlling potential exposure to hydrazine during maintenance of the F-16 aircraft is discussed. The effects of exposure to hydrazine on the skin, eyes, air passages, lungs, the central nervous system, and the liver are described. A maximum eight hour time weighted average airborne concentration of hydrazine to which personnel may be exposed is 0.10 ppm oor 0.13 mg/cu m; procedures for evaluating exposure to hydrazine during aircraft maintenance activities are analyzed. The development of a closed system for maintenance of the F-16 emergency power unit is examined. I.F.

**A86-38382**

**DESIGN, SAFETY, AND MAINTAINABILITY ASPECTS FOR HYDRAZINE USE IN EMERGENCY SECONDARY POWER SYSTEMS**

E. V. SCICCHITANO and E. J. BUNDAS (Grumman Aerospace Corp., Bethpage, NY) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 10 p.
(SAE PAPER 851972)

Emergency power system evaluation will be briefly considered since the approach selected is dependent upon aircraft mission. A rationale for the selection of hydrazine as a primary system, or in conjunction with other systems, has been developed. This paper will address the influence of safety and maintainability considerations upon hydrazine systems design. Concerns in these areas have limited the widespread use of hydrazine in aircraft secondary power systems. To dispel these concerns, extensive experience accumulated to date with hydrazine is examined and applied to operational considerations to provide increased confidence required in considering hydrazine as a viable candidate energy source for aircraft secondary power systems. Author

**A86-38511**

**DATA FOR THE DEVELOPMENT OF CRITERIA FOR GENERAL AVIATION SEAT AND RESTRAINT SYSTEM PERFORMANCE**

R. F. CHANDLER (FAA, Civil Aeromedical Institute, Oklahoma City, OK) IN: Crash dynamics of general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 13-28. refs
(SAE PAPER 850851)

The recommendations of the General Aviation Safety Panel (GASP) for improving crash injury protection in small aircraft are described. A two test procedure for seat and restraint systems was developed. The first test involves forward and downward loading on a seat using a 170 lb dummy and providing an impact velocity of 31 ft/s with a duration of 0.1 s and the second procedure is a forward impact test with an impact velocity of 42 ft/s acting 10 deg to one side of the seat for a 0.1 s duration. The test facility and equipment employed to evaluate the test procedures are examined. The combined vertical and forward test data on seat pan fabrics and adhesive bonds, the elasticity of the adjustment mechanism, armrests, pelvic and shoulder belt load limitations, and head impact are analyzed. The tests revealed that the procedures recommended by GASP provide appropriate performance goals for the seat and restraint systems of small aircraft. I.F.

**A86-39553**

**LOW ALTITUDE WIND-SHEAR PROTECTION CAN BE ATTAINED**

L. M. GREEN (Safe Flight Instrument Corp., White Plains, NY) ICAO Bulletin, vol. 41, April 1986, p. 10-13.

The development of reliable, highly redundant, and self-contained airborne wind shear warning (WSW) recovery guidance (RG) system designed to complement the ground-based systems to effectively protect against sudden and severe wind shear encounters is described. The WSW system, which includes a radio altimeter, continuously computes the aircraft performance loss due to the combined horizontal and vertical forces of wind shear, and gives audiovisual warnings as the aircraft starts to enter a shear, in time for performance (in nine or more seconds) of a successful recovery maneuver. The RG system then continuously computes attitude guidance for recovery displayed on the pitch command bars of the flight director, requiring the pilot only to follow the command bars to produce the best possible climb profile. Simulator results are discussed. I.S.

**N86-26295#** Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.

**A DEMONSTRATION EXPERT SYSTEM FOR IMPLEMENTING EMERGENCY PROCEDURES IN A HIGH-PERFORMANCE FIGHTER AIRCRAFT**

B. L. BELKIN Apr. 1986 14 p refs

(MAE-1749) Avail: NTIS HC A02/MF A01

A demonstration expert system was developed using a knowledge acquisition tool to simulate the operation of an electronic pilot's assistant operating on-board a high-performance fighter aircraft. The task selected for this simulation was the implementation of in-flight emergency procedures for the canopy loss scenario described in the F-16 Flight Manual. Four modes of pilot assistance operation were identified. Two modes require the Electronic Pilot's Assistant to help the pilot with routine flight tasks. The other two modes require the Electronic Pilot's Assistant to autonomously plan and execute procedures to maintain control of the aircraft in the event the pilot is incapacitated or subject to unmanageable workload. Author

**N86-26296*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LIGHTNING DISCHARGE PROTECTION ROD Patent Application**

C. F. BRYAN, JR., inventor (to NASA) 24 Apr. 1986 14 p

Sponsored by NASA

(NASA-CASE-LAR-13470-1; NAS 1.71:LAR-13470-1; US-PATENT-APPL-SN-855983) Avail: NTIS HC A02/MF A01 CSCL 01C

This invention is a system for protecting an in-air vehicle from damage due to the craft sustaining a lightning strike. It is an extremely simple device consisting of a sacrificial graphite composite rod, approximately the diameter of a pencil with a length of about five inches. The sacrificial rod is constructed with the graphite fibers running axially within the rod in a manner that best provides a path of conduction axially from the trailing edge of an aircraft to the trailing end of the rod. The sacrificial rod is inserted into an attachment hole 32 machined into trailing edges of aircraft flight surfaces, such as vertical fin cap 31, and attached with adhesive in a manner not prohibiting the conduction path between the rod and aircraft. The trailing end of rod may be tapered for aerodynamic and esthetic requirements. This rod is sacrificial but has the capability to sustain several lightning strikes and still provide protection. The novelty of this invention appears to reside in a system for protecting the most vulnerable parts of an in-air vehicle when the craft is hit by lightning with an extremely simple and inexpensive device. The materials are easily procured and the sacrificial rod generally can be constructed from the same composite as the flight or control surface to be protected. The protection extends to several in-air lightning strikes and provides protection to aircraft parts manufactured from all materials including organic composites. NASA

**N86-26298#** Simula, Inc., Phoenix, Ariz.

**CRASH-RESISTANT CREWSEAT LIMIT-LOAD OPTIMIZATION THROUGH DYNAMIC TESTING WITH CADAVERS Final Report, May 1979 - Dec. 1985**

J. W. COLTMAN, C. V. INGEN, and F. SELKER Jan. 1986 112 p

(Contract DAAK51-79-C-0016; DA PROJ. 1L1-62209-AH-76)

(AD-A164828; TR-85422; USAAVSCOM-TR-85-D-11) Avail: NTIS HC A06/MF A01 CSCL 01B

The threshold of spinal injury for seated humans subjected to +Gz loading was investigated. The +Gz loading was induced by simulating crash conditions typically found in helicopter crashes, and modified by the use of energy-absorbing mechanisms incorporated in the seat structure. Fifteen tests were conducted with unembalmed cadavers as human surrogates at various limit-load settings to attempt to identify the load threshold causing spinal injury. Bone strength analysis was used to normalize the results of the cadaver test program. Performance data and autopsy results for the 15 crash tests are presented. A correlation was derived relating the frequency of spinal injury to the energy absorber limit-load factor for use in design of crashworthy seating systems. Comparison of the incidence of spinal injury between the experimental test data developed through testing with cadavers and field performance of production energy-absorbing seats is discussed. The report also contains a discussion of the biomechanics of trauma associated with the human spine, including mechanical properties of the spine, typical injury mechanisms for +Gz loading, and theoretical models for predicting injury. GRA

**N86-26299#** Coordinating Research Council, Inc., Atlanta, Ga.

**FLAMMABILITY OF AIRCRAFT HYDRAULIC FLUIDS: A BIBLIOGRAPHY**

Jan. 1986 46 p refs

(Contract DAAK70-86-C-0011)

(AD-A165463; CRC-546) Avail: NTIS HC A03/MF A01 CSCL 11H

As part of an overall effort to collect flammability data on aircraft fluids, a critical survey was made of the aircraft hydraulic oil literature, with particular emphasis on flammability testing and flammability characteristics of existing and projected aircraft hydraulic fluids. Commercial aviation and military aviation fluids are treated separately, in view of their divergent development. Flammability test procedures are described. Flammability test results and other inspection tests are given for a variety of current and proposed aircraft hydraulic fluids. GRA

**N86-26301#** National Transportation Safety Board, Washington, D. C. Bureau of Safety Programs.

**TRANSPORTATION SAFETY RECOMMENDATIONS ADOPTED DURING THE MONTH OF DECEMBER 1985**

1986 95 p

(PB85-916612; NTSB-REC-85-12) Avail: NTIS MF A01; also available on subscription, North American Continent price HC $65.00/year; all others write for quote CSCL 01B

The publication contains safety recommendations in aviation, highway and marine modes of transportation adopted by the National Transportation Safety Board during the month of December, 1985. GRA

**N86-26302#** National Transportation Safety Board, Washington, D. C. Bureau of Technology.

**SAFETY REPORT GENERAL AVIATION CRASHWORTHINESS PROJECT. PHASE 3: ACCELERATION LOADS AND VELOCITY CHANGES OF SURVIVABLE GENERAL AVIATION ACCIDENTS Report, 1972 - 1981**

4 Sep. 1985 187 p

(PB85-917016; NTSB-SR-85-02) Avail: NTIS MF A01; also available on subscription, North American Continent price HC $60.00/year; all others write for quote CSCL 01C

The report is the last in a series of three reports issued by the National Transportation Safety Board as a result of its General Aviation Crashworthiness Program. The purpose of the program is to provide information to support changes in crashworthiness design standards for seating and restraint systems in general aviation airplanes. A Phase One report presents a methodology for documenting impact severity. A Phase Two report presents specific data on survivable accidents which demonstrate that if all occupants wear shoulder harnesses, fatalities are expected to be reduced by 20 percent. Eighty-eight percent of the seriously injured persons in survivable crashes are expected to experience significantly fewer life-threatening injuries. The Phase Three report provides analytical results of actual crashes. The values of acceleration loads and velocity changes that occupants can sustain in survivable, modern aviation airplane accidents are defined. GRA

**N86-26303#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 3 OF 1984 ACCIDENTS**

18 Oct. 1985 421 p
(PB85-916922) Avail: NTIS HC A18/MF A01; paper copy also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

Selected aircraft accident reports in brief format occurring in the U.S. civil and foreign aviation operations during calender year 1984 are presented. Approximately 200 general aviation and air carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The brief format represent the facts, conditions, circumstances, and probable causes for each accident. GRA

**N86-26304#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 4 OF 1984 ACCIDENTS**

14 Nov. 1985 416 p
(PB85-916923; NTSB-AAB-85-23) Avail: NTIS HC A18/MF A01; paper copy also available on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

This fourth issue contains selected aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during calender year 1984. Approximately 200 general aviation and air carrier accidents contained in the publication are selected at random. The publication is issued approximately eighteen times each year at irregular intervals. The brief format contains the facts, conditions, circumstances, and probable cause(s) for each accident. GRA

**N86-26305#** National Transportation Safety Board, Washington, D. C.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 5 OF 1984 ACCIDENTS**

24 Jan. 1986 418 p
(PB86-916901; NTSB-AAB-86-01) Avail: NTIS HC A03/MF A01; paper copy also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable causes(s) for each accident. Issue 5 includes file numbers 801 through 1000. GRA

**N86-26306#** National Transportation Safety Board, Washington, D. C.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 6 OF 1984 ACCIDENTS**

24 Jan. 1986 418 p
(PB86-916902; NTSB-AAB-86-02) Avail: NTIS HC A18/MF A01; paper copy also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. Issue 6 includes file numbers 1001 through 1200. GRA

**N86-26307#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 7 OF 1984 ACCIDENTS**

22 Nov. 1985 421 p
(PB86-916903; NTSB-AAB-86-03) Avail: NTIS HC A18/MF A01; paper copy also avail. on subscription, North America Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. Issue 7 includes file numbers 1201 through 1400. GRA

**N86-26308#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 8 OF 1984 ACCIDENTS**

22 Nov. 1985 421 p
(PB86-916904; NTSB-AAB-86-04) Avail: NTIS HC A18/MF A01; paper copy also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. Issue 8 includes file numbers 1401 through 1600. GRA

**N86-26309#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.

**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 9 OF 1984 ACCIDENTS**

29 Nov. 1985 400 p
(PB86-916905; NTSB-AAB-86-05) Avail: NTIS HC A17/MF A01; paper copy also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during calendar year 1984. Approximately 200 general aviation and air carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The brief format represents the facts, conditions, circumstances and probable cause(s) for each accident. Issue 9 includes file numbers 1601 through 1800. GRA

**N86-26310#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 11 OF 1984 ACCIDENTS**
16 Dec. 1985 418 p
(PB86-916907; NTSB-AAB-86-07) Avail: NTIS HC A18/MF A01; also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times a year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. Issue 11 includes file numbers 2001 through 2200. GRA

**N86-26311#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
**AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 13 OF 1984 ACCIDENTS**
30 Dec. 1985 412 p
(PB86-916909; NTSB-AAB-86-09) Avail: NTIS HC A18/MF A01; also avail. on subscription, North American Continent price $185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. Issue 13 includes file numbers 2401 through 2600. GRA

**N86-27267#** National Transportation Safety Board, Washington, D. C.
**NATIONAL TRANSPORTATION SAFETY BOARD SAFETY RECOMMENDATION**
4 Mar. 1986 6 p
(NTSB-4102C/300A) Avail: NTIS HC A02/MF A01

Vibrations caused by open air start access doors on Lockheed Electras were discussed. Proposed safety measures include: issuance of an Airworthiness Directive to all Electra operators to modify the air start access door; until modification of the door occurs, Principle Operations Inspectors should inform the operators of the potential hazards; establish procedures to ensure adequate surveillance is maintained; verification that supplemental operators are fulfilling their responsibility to see that competent personnel are available to maintain and service the aircraft; evaluate information needed by the crash/fire rescue agencies; and provide guidance on topics and training in cockpit resource management to flightcrew members. B.G.

**N86-27268*#** Wichita State Univ., Kans. Coll. of Engineering.
**ANALYSES AND TESTS FOR DESIGN OF AN ELECTRO-IMPULSE DE-ICING SYSTEM Interim Report**
G. W. ZUMWALT, R. L. SCHRAG, W. D. BERNHART, and R. A. FRIEDBERG May 1985 198 p
(Contract NAG3-284)
(NASA-CR-174919; AR-85-1; NAS 1.26:174919) Avail: NTIS HC A09/MF A01 CSCL 01C

De-icing of aircraft by using the electro-magnetic impulse phenomenon was proposed and demonstrated in several European countries. However, it is not available as a developed system due to lack of research on the basic physical mechanisms and necessary design parameters. The de-icing is accomplished by rapidly discharging high voltage capacitors into a wire coil rigidly supported just inside the aircraft skin. Induced eddy currents in the skin create a repulsive force resulting in a hammer-like force which cracks, de-bonds, and expels ice on the skin surface. The promised advantages are very low energy, high reliability of de-icing, and low maintenance. Three years of Electo-Impulse De-icing (EIDI) research is summarized and the analytical studies and results of testing done in the laboratory, in the NASA Icing Research Tunnel, and in flight are presented. If properly designed, EIDI was demonstrated to be an effective and practical ice protection system for small aircraft, turbojet engine inlets, elements of transport aircraft, and shows promise for use on helicopter rotor blades. Included are practical techniques of fabrication of impulse coils and their mountings. The use of EIDI with nonmetallic surface materials is also described. Author

**N86-27269#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
**AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 17 OF 1983 ACCIDENTS**
12 Jul. 1985 337 p
(PB85-916918; NTSB/AAB-85/18) Avail: NTIS HC A15/MF A01; also available on subscription, North American Continent HC$185.00/year; all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1983. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. GRA

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-37334**
**FLIGHT TEST WITH A TERRAIN AIDED NAVIGATION SYSTEM**
E. SKARMAN (Saab Missiles AB, Linkoping, Sweden) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 19.1-19.5. Research supported by the Forsvaret Materielverk.

This article presents flight tests with a terrain-aided inertial navigation system. The system is essentially a nonlinear Kalman filter. The flight tests have been performed in a Sabreliner aircraft, with an altimeter and a strapdown sensor package. The results confirm the simulation model used before, and indicate an 1-sigma error level below 50 m. Author

**A86-37336**
**GROUND CONTROL STATION FOR RPVS**
S. JONES (Ferranti Computer Systems, Ltd., Bracknell, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 22.1-22.4.

The ground control stations (GCSs) that furnish an interface between RPVs and their tasking agencies may operate autonomously or by way of a coordinating headquarters. Automatic facilities are used for the allocation of tasks to an RPV, for the generation of detailed routing instructions, and for the transmission of these instructions to the RPV. GCS flexibility is obtained through the use of a variety of manual overrides; the GCS also observes sensor imagery, and generates and transmits reports. Attention is given to mission planning and execution, man/machine interfaces, and communications. O.C.

**A86-37555**

**A TECHNIQUE TO EVALUATE THE ACCESSIBILITY OF AIRBORNE RECEIVERS TO INTERFERING SIGNALS**

D. P. KOESTER, C. E. COOK, and R. R. STEVENS (Mitre Corp., Bedford, MA) IN: ICC '85; International Conference on Communications, Chicago, IL, June 23-26, 1985, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 814-821. refs

Techniques to evaluate the accessibility of modern military airborne receivers to tactical jammers are described. Signal detection capabilities of the equipment are analyzed in relation to system performance. Problems encountered in examining adaptive antenna arrays are discussed. The procedures for calculating operability volumes are studied. The effects of radio horizon and terrain on line-of-sight communications are investigated. The contours of maximum communications range are estimated and utilized to evaluate the communications performance for a system configuration and an interference environment. I.F.

**A86-38974**

**EXPERIMENTAL AND THEORETICAL STUDY OF THE EFFECT OF WAVE PROPAGATION ON THE POSTITIONAL ACCURACY OF OMEGA NAVIGATION IN GERMANY [EXPERIMENTELLE UND THEORETISCHE UNTERSUCHUNG UEBER DEN EINFLUSS DER WELLENAUSBREITUNG AUF DIE STANDORTGENAUIGKEIT DER OMEGA-NAVIGATION IN DEUTSCHLAND]**

S. BLOCH Braunschweig, Tehnische Universitaet, Fakultaet fuer Maschinenbau und Elektrotechnik, Dr.-Ing. Dissertation, 1984, 290 p. In German. refs

The utilization of the Omega navigational system in southern Germany under given reception and interference conditions is studied. A series of measurements conducted at Stuttgart at various times of day and year is reported. The essential characteristics and variables of VLF propagation are analyzed and discussed, taking into account specific physical relationships which affect the system in Germany. Multifrequency procedures aimed at making the Omega positional determination more independent of ionospheric behavior are discussed. C.D.

**A86-39048*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**FUEL CONSERVATIVE GUIDANCE FOR SHIPBOARD LANDING OF POWERED-LIFT STOL AIRCRAFT**

D. N. WARNER, JR., L. A. MCGEE (NASA, Ames Research Center, Moffett Field, CA), J. D. MCLEAN, and G. K. SCHMIDT (Analytical Mechanics Associates, Inc., Mountain View, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 307-317) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 377-379. Previously cited in issue 22, p. 3225, Accession no. A85-45911.

**A86-39535*** Ohio State Univ., Columbus.

**SIMULATION AND ANALYSIS OF ANTENNAS RADIATING IN A COMPLEX ENVIRONMENT**

J. J. KIM (Texas Instruments, Inc., McKinney, TX) and W. D. BURNSIDE (Ohio State University, Columbus) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. AP-34, April 1986, p. 554-562. refs

(Contract NSG-1498)

A numerical procedure for computing the high-frequency radiation patterns of antennas mounted on curved surfaces is described. The procedure utilizes the uniform geometrical theory of diffraction to examine the antenna system's performance, which is dependent on antenna radiation patterns. Composite ellipsoid models of fuselage shapes are developed and the formation of geodesic paths on the models is studied; the shape of the fuselage affects the radiation patterns. The actual field radiated by the source and scattered by the structure is calculated using the ray field technique. The numerical solution is applied to the analysis of the antenna radiation patterns of a military aircraft, private aircraft, and the Space Shuttle orbiter. Good correlation between the calculated and measured radiation patterns is noted verifying the usefulness and accuracy of the numerical procedure. I.F.

**A86-39557**

**MLS - THE PILOT'S POINT OF VIEW [MLS - LE POINT DE VUE DU PILOTE]**

MR. RENOUARD (Union de Transports Aeriens, Puteaux, France) (Seminaire sur le Systeme d'Atterrissage Hyperfrequences 'MLS' Toulouse, France, Nov. 26, 27, 1985) Navigation (Paris) (ISSN 0028-1530), vol. 34, April 1986, p. 145-166. In French.

The benefits and difficulties associated with implementing the Microwave Landing System (MLS) as standard equipment for airline passenger aircraft are considered. MLS offers an elimination of local signal distortions, three-dimensional guidance devoid of local reflectances, and usefulness even when the runway disappears beyond local terrain relief. The precision exceeds that available from current systems during categories I and II landings. Finally, calibration is easier and cheaper. The switchover to MLS from ILS is to be performed over a 12 yr period, implying that the aircraft must carry two different landing guidance systems and pilots must be qualified to operate both of them. The long period of transition would cause a higher fuel consumption rate. It is noted that current display systems do not provide the information in a clear manner, and could be improved by including the MLS in digital display CRT systems, particularly in concert with meteorological displays. Similarly, the MLS and ILS systems could be interoperative and use the same display. Tests are still needed to determine the operability of MLS during category III approaches. Finally, the various on board equipment and procedures associated with implementation of the MLS are discussed. M.S.K.

**A86-39558**

**AIR TRAFFIC CONTROL (ATC) AND VESSEL TRAFFIC SYSTEMS (VTS) [CONTROLE DU TRAFIC AERIEN (ATC) ET SYSTEMES DE TRAFIC DES NAVIRES (VTS)]**

MR. GUICHAROUSSE Navigation (Paris) (ISSN 0028-1530), vol. 34, April 1986, p. 167-179. In French.

The requirements of ATC and marine vessel traffic control (VTS) are compared to demonstrate that existing procedures cannot be gainfully transferred between the two. ATC prevents close approaches between aircraft and between aircraft and other obstructions, and facilitates an orderly, optimized flow of air traffic. Clearances are established among aircraft in terms of the time of flight and the lateral and vertical distances between aircraft. The eyes of the pilots are the primary sensors during visual flight rules, i.e., favorable weather, and are augmented by ATC updates, precision radar systems and ILS approach systems during limited visibility conditions. The ATC therefore has an indispensible role, something that is not true for VTS, since marine vessels can stop almost anywhere and can survive unscheduled stops such as groundings. Separation distances between ships are two-dimensional and horizontal. Ships cannot turn around once inside a channel, and their maneuvering stability can be greatly affected simultaneously by wind forces, currents and tidal streams. The amount of time required for a large vessel to stop or turn can be a significant fraction of an hour. Once committed to a channel or port area and having obtained information from the VTS by VHF phone, ship pilots make few demands on the VTS because too much attention is needed for monitoring what can be an extremely varying array of traffic vessels approaching from every direction, with only radar available as a navigational aid. M.S.K.

**A86-39561**

**A MINIMUM ROUTE TIME (MRT) PROGRAM FOR MICROCOMPUTERS [PROGRAMME DE ROUTE A TEMPS MINIMUM (R.T.M.) POUR MICRO-ORDINATEUR]**

B. GARCON-DUFOUR (Air France, Direction des Operations Aeriennes, Roissy, France) Navigation (Paris) (ISSN 0028-1530), vol. 34, April 1986, p. 207-212. In French.

A program for minimizing flight distances is presented that requires only kilobytes of RAM and therefore can be run on a microcomputer. Isochronous curves are drawn between two points and points requiring equal flight times, hour-by-hour, to reach are identified relative to a straight-line distance between airports. The map of shortest-distance points is thereby generated by mapping the shortest routes for an isobaric flight, for the shortest great circle route, and the shortest route with wind perpendicular to the flight path being taken into account. Corrections are introduced for the different altitudes of departure and arrival, for changes in the strength and direction of the wind, and the air temperature along the routes. Geographic coordinates are then interpolated for the identified shortest route. A sample routing plan is worked out for a 200 nm flight. It is noted that accuracy will be enhanced if two sets of computations are carried out using successive weather maps having the same degree of validity. M.S.K.

**A86-39562**
**THE PRESENCE OF THE TRIDENT III ON ANTARCTICA [PRESENCE DU TRIDENT III SUR LE CONTINENT ANTARCTIQUE]**
B. DUMAS (Thomson-CSF, Division Avionique Spatiale et Aviation Generale, Issy-les-Moulineaux, France) Navigation (Paris) (ISSN 0028-1530), vol. 34, April 1986, p. 223-237. In French.

The Trident III navigation system was installed at several sites and on several aircraft stationed in Antarctica in support of the GANOVEX IV scientific experiments carried out in 1984-85. The airborne platforms were two Dornier 228 aircraft fitted with magnetometers and the CCNS/Trident equipment for aeromagnetism surveys and precision navigation, respectively. The measurements were carried out over a 240,000 sq km region bounded by Ross and Coulman Islands, the polar plateau and the Ross Sea. Nine solar powered ground beacons were established for the Trident system, and situated in groups by elevation from sea level to 3 km altitude. The ground stations were equipped with either omnidirectional or directional antennas to fit the demands of the flight plans. Two interrogator antennas accessing the ground beacons from the two aircraft were coupled to CCNS data analysis computers, which worked continuously in real time acquiring and recording position data. Occasional failures were encountered among the shoreline beacons due to continuous snow or icing conditions blocking off solar energy for several days at a time. The positioning accuracies obtained using the system are estimated to be within 20-40 m for the 40,000 sq km of coverage accomplished. M.S.K.

**A86-39766#**
**AN TERRAIN-AIDED GUIDANCE SYSTEM WITH HIGH CONVERGENCE SPEED**
M. JI (Changsha Institute of Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, April 1986, p. 173-180. In Chinese, with abstract in English. refs

A parallel Kalman filter system for terrain-aided guidance, based on the theory of Gaussian Sum in order to meet the requirement of locating flying vehicles with large initial position error, is presented. An order-reduced model is put forth, based on the error analysis of which an adaptive sequential decision (ASD) method is presented. By combining these, the position uncertainty and the amount of calculation can be decreased in steps, and the real-time calculation can be implemented. The performance analysis of ASD gives a practical way to further increase the speed of convergence. It is shown that a fast and accurate location can be provided by the system for a vehicle even with large errors in position, velocity and course. Author

**N86-26312*#** Princeton Univ., N. J. Dept. of Civil Engineering.
**INTEGRATED RISK/COST PLANNING MODELS FOR THE US AIR TRAFFIC SYSTEM**
J. M. MULVEY and S. A. ZENIOS Dec. 1985 41 p refs
(Contract NAG1-520; NSF DCR-84-01098)
(NASA-CR-177274; NAS 1.26:177274; EES-85-9) Avail: NTIS HC A03/MF A01 CSCL 17G

A prototype network planning model for the U.S. Air Traffic control system is described. The model encompasses the dual objectives of managing collision risks and transportation costs where traffic flows can be related to these objectives. The underlying structure is a network graph with nonseparable convex costs; the model is solved efficiently by capitalizing on its intrinsic characteristics. Two specialized algorithms for solving the resulting problems are described: (1) truncated Newton, and (2) simplicial decomposition. The feasibility of the approach is demonstrated using data collected from a control center in the Midwest. Computational results with different computer systems are presented, including a vector supercomputer (CRAY-XMP). The risk/cost model has two primary uses: (1) as a strategic planning tool using aggregate flight information, and (2) as an integrated operational system for forecasting congestion and monitoring (controlling) flow throughout the U.S. In the latter case, access to a supercomputer is required due to the model's enormous size. Author

**N86-26315#** Federal Aviation Agency, Atlantic City, N.J.
**MATH MODEL STUDY OF A PROPOSED GLIDE SLOPE FOR RUNWAY 13R, DALLAS-FORT WORTH AIRPORT, TEXAS**
J. WALLS Jan. 1986 19 p refs
(AD-A164907; DOT/FAA/CT-TN85/80) Avail: NTIS HC A02/MF A01 CSCL 01E

This document describes instrument landing system (ILS) math modeling performed at the request of the Southwest Region. Data are presented showing the computed performance of a proposed glide slope for runway 13R at the Dallas-Fort Worth Airport, Texas. Model path structure and level run plots are provided for capture effect, null reference, and sideband reference systems installed at a location selected by region engineers. Results indicate that all three systems should meet category II path structure, linearity, and symmetry tolerances. The capture effect system provides the smoothest glidepath structure of the three systems modeled. Author (GRA)

**N86-26316#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
**GUIDANCE-CONTROL-NAVIGATION AUTOMATION FOR NIGHT ALL-WEATHER TACTICAL OPERATIONS**
Loughton, England Oct. 1985 136 p refs In ENGLISH and FRENCH The 40th Guidance and Control Panel Symposium was held at The Hague, Netherlands, 21-24 May 1985
(AGARD-CP-387; ISBN-92-835-0381-3) Avail: NTIS HC A07/MF A01

The components, functions, and systems integration required to support the evolution of alternative guidance/control/navigation systems capable of enabling effective and routine night all-weather operations are discussed. Papers are organized under the following headings: operational requirements, systems concepts and integration issues, man-machine interface, terrain reference systems, and mission applications.

**N86-26324#** Harris Government Aerospace Systems Div., Melbourne, Fla. Digital Cartographic Programs.
**APPLICATIONS OF DIGITAL TERRAIN DATA IN FLIGHT OPERATIONS**
G. W. CANTRELL *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 24 p Oct. 1985
Avail: NTIS HC A07/MF A01

With the availability of a world-wide digital terrain data base becoming a reality, it is now possible to carry and display on a tactical aircraft all of the map information needed for a mission. Along with the map display on a color cathode-ray tube (CRT), current targets and mission-specific data can be shown. The limitations of today's commonly used film readers are eliminated by using a digital data base which contains elevation information; one such data base is the U.S. Defense Mapping Agency's Digital Land Mass System (DLMS). The terrain data can be digitally compressed and efficiently stored so that large area coverages may be achieved. With this information readily available, aircraft mission effectiveness and survivability can be enhanced. The system for accomplishing this task is called a digital map generator (DMG). The DMG architecture encompasses data storage, data access and reconstruction, data display processing, and data formatting for use by other aircraft subsystems. A DMG architecture was developed for application in low-level or nap-of-the-Earth tactical missions, as well as long range strategic missions. Mission capabilities are enhanced by using this DMG to support terrain following/terrain avoidance (TF/TA), autonomous navigation, threat avoidance, and weapons delivery. In addition, the same digital processing approach is usable for pre-flight mission planning. The ability to plan a flight using the actual mission data base gives the pilot the ability to see exactly where he will be at all times and to determine safe corridors for entry and departure, making maximum use of terrain shielding. Similarly, the terrain data may be used for reference during post-mission debriefing, in which the pilot can refer to in-flight annotations made through the DMG subsystem. Author

**N86-26325#** Theory and Applications Unlimited Corp., Los Gatos, Calif.

**A NEW TECHNIQUE FOR TERRAIN FOLLOWING/TERRAIN AVOIDANCE GUIDANCE COMMAND GENERATION**

R. V. DENTON, J. E. JONES, and P. L. FROEBERG *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 11 p Oct. 1985 refs

Avail: NTIS HC A07/MF A01

A real-time optimization technique that efficiently generates a robust, optimum terrain following/terrain avoidance (TF/TA) trajectory, and has the structural capability for adding threat avoidance is described. The TF/TA technique presented is based on definition of a performance measure that is systematically optimized in real-time. The approach uses on-board Defense Mapping Agency digital terrain elevation data extensively, as updated by real-time sensor inputs. The optimization of the performance measure embodies the real-time trade-off of flying over (TF) versus flying around terrain features (TA). The performance measure is defined to generally penalize large excursions from the nominal (globally-defined) route, while rewarding a trajectory that achieves better terrain masking than contained in the nominal, mission-planned route. Direct incorporation of limits on the flight control variables (bank angle, roll rate, normal acceleration, etc.) is included within the procedure. The TF/TA technique also addresses additional considerations that apply when combining the TF/TA flight trajectory computation with maneuvers through mission waypoints. This involves several subtleties associated with the relative importance of the turning maneuver desired versus the normally applicable TF/TA performance measure. Finally, the relevance of this work to other advances in trajectory computation is described. This includes the relationship to global trajectory generation, and to integrated TF/TA with threat avoidance TF/(TA)2. Author

**N86-26327#** Crouzet Aerospace and Systems, Valence (France). Div. Aerospatiale.

**A MISSION NAVIGATION AND CONTROL SYSTEM FOR MODERN MILITARY HELICOPTERS [UN SYSTEME DE NAVIGATION ET DE GESTION DE LA MISSION POUR LES HELICOPTERS MILITAIRES MODERNES]**

J. L. ROCH *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 10 p Oct. 1985 In FRENCH

Avail: NTIS HC A07/MF A01

The requirements of modern military helicopters have fostered the development of navigation systems which use position sensors as a part of a centralized mission control system. An overview of the requirements for modern operational helicopter systems is given, as well as current automatic navigation systems; this is followed by a report of the NADIR MK2 mission navigation and control system developed by the CROUZET Company. Transl. by T.R.

**N86-27271*#** Princeton Univ., N. J. School of Engineering and Applied Science.

**AN OPTIMIZATION MODEL FOR THE US AIR-TRAFFIC SYSTEM Final Report**

J. M. MULVEY Apr. 1986 27 p

(Contract NAG1-520)

(NASA-CR-177277; NAS 1.26:177277) Avail: NTIS HC A03/MF A01 CSCL 17G

A systematic approach for monitoring U.S. air traffic was developed in the context of system-wide planning and control. Towards this end, a network optimization model with nonlinear objectives was chosen as the central element in the planning/control system. The network representation was selected because: (1) it provides a comprehensive structure for depicting essential aspects of the air traffic system, (2) it can be solved efficiently for large scale problems, and (3) the design can be easily communicated to non-technical users through computer graphics. Briefly, the network planning models consider the flow of traffic through a graph as the basic structure. Nodes depict locations and time periods for either individual planes or for aggregated groups of airplanes. Arcs define variables as actual airplanes flying through space or as delays across time periods. As such, a special case of the network can be used to model the so called flow control problem. Due to the large number of interacting variables and the difficulty in subdividing the problem into relatively independent subproblems, an integrated model was designed which will depict the entire high level (above 29000 feet) jet route system for the 48 contiguous states in the U.S. As a first step in demonstrating the concept's feasibility a nonlinear risk/cost model was developed for the Indianapolis Airspace. The nonlinear network program --NLPNETG-- was employed in solving the resulting test cases. This optimization program uses the Truncated-Newton method (quadratic approximation) for determining the search direction at each iteration in the nonlinear algorithm. It was shown that aircraft could be re-routed in an optimal fashion whenever traffic congestion increased beyond an acceptable level, as measured by the nonlinear risk function. B.W.

**N86-27272#** Massachusetts Inst. of Tech., Lexington.

**TCAS EXPERIMENTAL UNIT (TEU) HARDWARE DESCRIPTION**

D. A. SPENCER, R. R. LAFREY, J. DIBARTOLO, and W. H. HARMAN 6 Jun. 1986 129 p

(Contract F19628-85-C-0002; DOT-FA77WAI-817)

(FAA/PM-85/2; PR-ATC-133) Avail: NTIS HC A07/MF A01

The hardware design of the TCAS Experimental Units (TEU's) constructed by Lincoln Laboratory to support the design and validation of the Traffic Alert and Collision Avoidance System (TCAS) for the FAA is described. Section 1.0 presents an overview of the operation of the TEU's in order to give some context for the hardware design. References are given to more extensive descriptions of the TCAS system operation and software design. Section 2.0 constitutes the bulk of the report, and is a detailed description of the TEU hardware design. The purpose of this description is to document the design details of the equipment which was used to develop and validate the signal processing techniques and algorithms which appear in the TCAS II Minimum Operational Performance Standard, the TCAS National Standard and various technique reports listed in the references. A second purpose is to provide design guidance to potential TCAS II manufacturers, in the form of a detailed description of a feasible design with documented performance. Finally, this document is a manual for future use and maintenance of the TEU's. Author

**N86-27273#** Federal Aviation Agency, Atlantic City, N.J.
**TECHNICAL SUPPORT OF THE WALL STREET/BATTERY PARK CITY HELIPORT MLS (MICROWAVE LANDING SYSTEM) PROJECT Technical Note, Jan. - Jun. 1985**
B. R. BILLMANN, J. H. ENIAS, and M. WEBB Dec. 1985 78 p
(AD-A165073; DOT/FAA/CT-TN85/58) Avail: NTIS HC A05/MF A01 CSCL 17G

During the winter and spring of 1985, the Federal Aviation Administration (FAA) Eastern Region in conjunction with the Guidance and Airborne Systems Branch at the FAA Technical Center conducted a demonstration of a Microwave Landing System (MLS) located at a downtown heliport. This report describes both the industry/user and FAA Technical Center activities during the evaluation period. It describes the evaluation methodology and addresses topics concerning both technical and operational issues. It also describes the helicopter procedures flown during this evaluation and provides an analysis of signal coverage and the user's subjective opinions concerning the acceptability and perceived workload associated with these procedures. It was concluded that MLS to heliports is a viable asset to the helicopter Instrument Flight Rules (IFR) community; however, its full benefits may not be realized in the Battery Park/Wall Street area without revisiting the necessity and demand for the New York Terminal Control Area (TCA) Visual Flight Rules (VFR) operating exclusion area. Author (GRA)

**N86-27275#** Litton Technische Werke, Freiburg (West Germany).
**IMPROVEMENT OF STRAPDOWN SYSTEM PERFORMANCE BY MEANS OF NUMERICAL METHODS Final Report, Dec. 1984**
H. BUITKAMP, K. ENDERLEIN, G. EVERETT, U. KIRCHHOFF, M. KLEINSCHMIDT, D. OZDES, and P. STEIERT Bonn Bundesministerium fuer Forschung und Technologie Nov. 1985 130 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-85-011; ISSN-0170-1339; LITEF-105-793) Avail: NTIS HC A07/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 27.50

Software methods to improve the performance of strapdown systems, and the simulation tools used in the analysis of system mechanisms are presented. Models of the inertial and external sensors to compensate for systematic errors; correct timing of the data flow of the sensors; multiposition alignment to eliminate the day-to-day repeatability of gyro biases; design control loops with optimal/suboptimal filters for special tasks of a strapdown unit (e.g., helicopter mission, initial alignment) are described. Kalman filters are used to reduce the influence of stochastic errors and for cross calibration of the sensors. ESA

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-37326**
**REMOTELY PILOTED VEHICLES; INTERNATIONAL CONFERENCE, 5TH, BRISTOL, ENGLAND, SEPTEMBER 9-11, 1985, PROCEEDINGS AND SUPPLEMENTARY PAPERS**
Conference sponsored by the Royal Aeronautical Society and University of Bristol. Bristol, England, University of Bristol, 1985. Proceedings, 174 p.; Supplementary Papers, 87 p. For individual items see A86-37327 to A86-37345.

The present conference gives attention to British Army and Navy RPV requirements, safe mini-RPV operation for civil users, high altitude meteorological RPVs, the British Army's Phoenix battlefield surveillance system, the CL-227 Rotary wing RPV, and the design of compact electromechanical actuators for RPV flight control. Also discussed are a thermal imaging payload for RPV applications, thermal-IR zoom optics for RPV sensors, the Phoenix RPV as sensor turret system, RPV flight testing with a terrain-aided navigation system, the real time simulation of a nonlinear RPV incorporating HUD-type color graphics, a flywheel-powered RPV launcher, and a compressed air-driven RPV launching system. O.C.

**A86-37328**
**THE DEVELOPMENT OF Z-2 REMOTELY PILOTED HELICOPTER**
W. X. CHUN (Nanjing Research Institute on Simulation Technique, People's Republic of China) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 6.1-6.12.

Z-2 is a research Remotely Piloted Helicopter (RPH) for feasibility study, developed by Nanjing Research Institute on Simulation Technique (NRIST). It is the first remotely piloted helicopter of 20-30 kg class (T-O weight) developed by the PRC, and success has been obtained in flight tests. This paper describes briefly the Z-2 RPH and its development process, giving informations and analyses, with special emphasis on the designing and building of the composite main rotor blades, the main technical problems encountered and the approaches to solve them, as well as the results of flight tests. Author

**A86-37329**
**HIGH ALTITUDE UNMANNED AIRCRAFT FOR METEOROLOGICAL APPLICATIONS - HIMET**
D. W. ALLEN (Theta Analysis and Systems, Ltd., Aldershot, England) and M. C. PUTTOCK (Thorn EMI Electronics, Ltd., Hayes, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 7.1-7.17. Research sponsored by the Ministry of Defence (Procurement Executive).

A design configuration study has been conducted for an RPV platform able to carry experimental payloads weighing up to 15 kg to an altitude of 50,000 ft, remaining on station at that altitude for up to 4 h. This RPV, designated 'HIMET', has in the course of the design process been defined with respect to airframe type, propulsion system type, weight budget compliance, and required performance. A turbojet-powered sailplane was ultimately chosen as the HIMET platform. Attention is given to autopilot and control system options, launch and recovery operations, and operational meteorological coverage. O.C.

**A86-37330**
**CANADAIR ROTARY WING, FULL SCALE ENGINEERING DEVELOPMENT. III**
R. J. ATKINS (Canadair, Ltd., Montreal, Canada) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 11.1-11.14.

The CL-227 is a rotary wing RPV which is about to enter full scale engineering development. Attention is presently given to the design changes and consequent performance improvements that have accumulated in the course of technology development testing, such as an increase in takeoff mass that has resulted in increased endurance and payload capability. Greater engine output, improved maintainability/reliability, and an enhanced continuous navigation capability are additional consequences of developmental changes in design. O.C.

**A86-37338**
**ENHANCED MISSION VERSATILITY OF THE AQUILA RPV SYSTEM**
G. S. MELOY and M. A. LEVIN (Lockheed Missiles and Space Co., Inc., Austin, TX) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 5.1-5.11.

A comprehensive account is given of the development history, design configurations, subsystems integrations, mission profiles, and performance capabilities of the U.S. Army's Aquila RPV Target Acquisition, Designation and Reconnaissance System. Aquila encompasses such operational capabilities as real time imagery, accurate guidance and navigation at maximum range, a highly stabilized multiple field-of-view payload, an antijam data link, a low observability airframe, and integrated logistics support. Attention is given to the Aquila mission's impact on system cost and complexity, and the spectrum of mission types that can be accommodated in virtue of Aquila's extensive use of modular/exchangeable design features. O.C.

**A86-37339**
**BOEING ROBOTIC AIR VEHICLE**
D. E. SLADOVNIK (Boeing Military Airplane Co., Wichita, KS) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 27.1-27.5.

Attention is given to the design features, operational capabilities and mission profiles of the BRAVE-200 Robotic Air Vehicle, which is a low-cost, mission-adaptable minidrone. The mission types encompassed by BRAVE-200's capabilities are destructive and disruptive air defense suppression and battlefield surveillance and reconnaissance. Navigation accuracy, loiter patterns, and mission area performance are all functions of specific mission requirements. O.C.

**A86-37340**
**THE PHOENIX AIR VEHICLE, ITS LAUNCH AND RECOVERY**
P. S. TURNER (Flight Refuelling, Ltd., Wimborne, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 10.1-10.9.

An account is given to the design features and launch and recovery procedures of the Phoenix RPV, with attention to the way in which simplicity, low detectability and mission criteria influenced design. The Phoenix RPV encompasses a 'taxi' module, comprising the aerodynamic surfaces and controls, engine, electrical generator, and parachute recovery system, on the one hand, and on the other a separate 'mission system pod' module. The advantages of a parachute recovery system are discussed. O.C.

**A86-37465**
**AIRCRAFT ICING OBSERVATIONS AND ANALYSIS**
W. SAND (Wyoming, University, Laramie) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA American Meteorological Society, 1985, p. 94-96.
(Contract USBR-7-07-83-V0001)

An account is given of the results of University of Wyoming aircraft icing effects studies concerned with the location and measurement of supercooled liquid water and with such cloud microphysical parameters as supercooled cloud droplet size spectra. The studies indicate that aircraft climb capability decreases due to icing could be predicted through the examination of the derived parameter designated 'potential accumulation'. Icing effects are illustrated photographically. O.C.

**A86-37770*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**FULL-SCALE TILT-ROTOR HOVER PERFORMANCE**
F. F. FELKER, M. D. MAISEL, and M. D. BETZINA (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, April 1986, p. 10-18. refs

The hover performance of three full-scale rotors was measured at the Ames Outdoor Aerodynamic Research Facility. The rotors, all designed for tilt-rotor aircraft, were the original metal blades for the XV-15 Tilt Rotor Research Aircraft, a set of composite, advanced technology blades for the XV-15, and a 0.658-scale model of the proposed V-22A Osprey (JVX) rotor. The composite advanced technology blades for the XV-15 were tested with several alternate blade root and blade tip configurations. This paper presents the performance of these three rotors, shows the effects of tip Mach number and root and tip configuration changes on rotor performance, and presents data on rotor wake velocity distributions and tip vortex geometry. Measured rotor performance is compared with theoretical predictions, and the discrepancies are discussed. Author

**A86-37772*** Maryland Univ., College Park.
**GUST RESPONSE OF HINGELESS ROTORS**
G. S. BIR and I. CHOPRA (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, April 1986, p. 33-46. refs
(Contract NAG1-375)

The gust response of a coupled hingeless rotor-fuselage system is studied in both hover and forward flight. Each rotor blade undergoes flap bending, lag bending, and torsional deflections. The blades are discretized into beam elements, each with fifteen nodal degrees of freedom. The fuselage is permitted three translational (vertical, longitudinal, and lateral) and two rotational (pitch and roll) degrees of freedom. The formulation considers a three-dimensional gust field wherein each gust velocity component can have an arbitrary variation in space and time. Aerodynamic loads are obtained using quasisteady strip theory. Wake-induced effects are introduced through dynamic inflow modeling. Dynamic stall and reverse flow effects are also included. Equations governing the rotor-fuselage gust response are linearized about the vehicle propulsive trim state and the blade steady-state defected positions, and solved by time integration. The effects of several parameters on the helicopter gust response are illustrated, including dynamic inflow, lag stiffness, forward speed, gust profile, gust penetration rate, and gust velocity direction. Author

**A86-37773**
**EFFECTIVENESS OF CURRENT DYNAMIC-INFLOW MODELS IN HOVER AND FORWARD FLIGHT**
G. H. GAONKAR (Florida Atlantic University, Boca Raton) and D. A. PETERS (Georgia Institute of Technology, Atlanta) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, April 1986, p. 47-57. refs
(Contract DAAG29-80-C-0092)

A brief overview of dynamic inflow theory is given, including its history and its dependence on experimental data. Some of the most extensive of this data, flapping response derivatives obtained in 1972-1974, indicated that theoretical predictions which included the best dynamic-inflow models of that time were qualitatively as well as quantitatively inaccurate. In this paper, these original flapping data (some of which have never been compared to theory in the literature) are compared with theory which includes a more recently developed model of dynamic inflow. The correlation is excellent at most frequencies and advance ratios, and the new model brings the theory into qualitative agreement with experiment in all conditions. Author

**A86-37774**
**A UNIFIED FORMULATION OF ROTOR LOAD PREDICTION METHODS**
R. E. HANSFORD (Westland Helicopters, Ltd., Yeovil, England) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, April 1986, p. 58-65. refs

The relative merits and limitations of the Modal Summation and Force Integration approaches to rotor load calculations are discussed. A simple analysis, called the Unified Formulation Method, is devised which converts a Modal Summation approach into Force Integration when necessary. Application to lag damper modeling resulted in an improved correlation of edgewise bending moments near the blade root. Further use of this method is demonstrated for load calculations of higher mode torsional forcings induced by varying pitching moments of advanced multiprofile blades. Author

**A86-37807#**
**AERODYNAMICS AND RADAR-SIGNATURE - A THEORETICAL APPROACH TO ESTIMATE THE RADAR-SIGNATURE OF COMPLEX AIRCRAFT CONFIGURATIONS COMPATIBLE WITH AERODYNAMIC PANEL-METHODS**
S. M. HITZEL (Dornier GmbH, Friedrichshafen, West Germany) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 46-52. refs
(AIAA PAPER 86-1770)

Combat-aircraft are threatened by radar-controlled anti-aircraft systems. Reduced radar-signature is a means to improve the capabilities to penetrate enemy defense systems. The knowledge of the back-scatter of electromagnetic waves from aircraft makes it possible to design a low radar-signature or at least to improve the tactics of aircraft already in service to avoid successful energy defence reaction. A theoretical approach is presented to estimate the radar-signatures of complex military aircraft-configurations including external stores. The signature is evaluated by the determination of the radar-cross-sections of intended radar-observation-directions. The radar-cross-section of a certain aspect view of a radar-observation is determined by the means of a combination of specular geometrical and physical optics with the evaluation of the radar-reflection characteristics of configuration elements being small compared to the radar's wave-length. The geometric input is equal to the build-up of usual aerodynamic panel-methods. Thus an aerodynamic surface-discretization can be used without modification. The signature of a fighter aircraft, armed and unarmed, exposed to typical radar illumination is presented. Author

**A86-37813*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**WIND TUNNEL TEST OF A MODEL ROTOR WITH A FREE-TIP**
R. H. STROUB (NASA, Ames Research Center, Moffett Field, CA), H. KUMAGAI (University of Kansas Center for Research, Inc., Lawrence), and C. KEYS (Boeing Vertol Co., Philadelphia, PA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 97-109.
(AIAA PAPER 86-1781)

A model helicopter rotor with a free tip was tested in a wind tunnel to show the effect of the free tip on rotor performance and oscillatory loads. The free-tip rotor has blade tips that are free to pitch independently of the remainder of the blade. A nearly constant pitching moment is applied to the tip so the tip will produce a nearly steady lift around the azimuth. The aerodynamic development of the free tip is reviewed. The development process concentrated on configuring the tip to have the capability of fast response to angle-of-attack perturbations. Wind tunnel test results show the free-tip rotor configuration requires less power than a fixed-tip configuration in forward flight. In addition, the free tip causes substantial reduction in blade-flapwise vibratory loads. However, blade-chordwise loads were increased. Pitch-link vibratory loads were also reduced by the free-tip configuration. Discussion is presented on the reasons that the use of the free tip caused reduced power and smaller vibratory loads. Author

**A86-37814*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**EXPERIMENTAL INVESTIGATION OF ROTORCRAFT HUB AND SHAFT FAIRING DRAG REDUCTION**
L. A. YOUNG and D. R. GRAHAM (NASA, Ames Research Center, Moffett Field, CA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 110-123. refs
(AIAA PAPER 86-1783)

A wind-tunnel test was conducted to obtain data on several rotorcraft hub and shaft fairing drag reduction configurations. Aerodynamic loads and moments were acquired for each test configuration. Limited wake pressure measurements and flow visualization (tuft) photographs were obtained for some configurations. All hub and shaft fairing configurations were tested on a 1/5-scale XH-59A model fuselage. Both coaxial and single rotor configurations were tested. All rotor assemblies were modeled with nonrotating hardware. The drag reduction methods tested included cambered elliptical hub fairings, several different shaft fairings, and strakes. Test data show that significant drag reductions can be attained with certain fairing configurations. The lowest drag values for the single rotor configurations were obtained for a cambered elliptical hub fairing with a large thickness airfoil shaft fairing. The lowest coaxial configuration drag values were obtained with cambered elliptical hub fairings and a long chord intermediate shaft fairing. Author

**A86-37843*#** Grumman Aerospace Corp., Bethpage, N.Y.
**APPLICATION OF NCOREL TO AIRCRAFT CONFIGURATIONS**
M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY) and J. L. PITTMAN (NASA, Langley Research Center, Hampton, VA) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 355-367. refs
(Contract NAS1-16758)
(AIAA PAPER 86-1830)

The NCOREL computer program and methodology (Grossman, 1979) modified for computation of flows over complex geometries is described. The newly introduced features include a more flexible grid-generation package, capable of generating grids for realistic wing-body cross sections, and a more general numerical method, developed for the capture of highly three-dimensional embedded, oblique shocks. In addition, an inlet capability is included, by means of which the cross section is allowed to change discontinuously with the addition of the inlet geometry. The new cross section is regridded and the potentials and their derivatives are interpolated for the marching to continue. Hence, a discontinuity in the grid or mappings is taken into account at the inlet station. The results of the flow-field computation for a realistic fighter configuration are discussed. I.S.

**A86-37849#**
**EULER CALCULATIONS FOR FLOWFIELD OF A HELICOPTER ROTOR IN HOVER**
R. K. AGARWAL and J. E. DEESE (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 425-433. Research sponsored by the McDonnell Douglas Independent Research and Development Program. refs
(AIAA PAPER 86-1782)

Aerodynamic loads on a multibladed helicopter rotor in hovering flight are calculated by solving the three-dimensional Euler equations in a rotating coordinate system on body-conforming curvilinear grids around the blades. Euler equations are recast in the absolute flow variables so that the absolute flow in the far field is uniform but the relative flow is nonuniform. Equations are solved for the absolute flow variables employing Jameson's finite-volume explicit Runge-Kutta time-stepping scheme. Rotor-wake effects are modeled in the form of a correction applied to the geometric angle of attack along the blades. This correction is obtained by computing the local induced downwash with a free-wake analysis program. The calculations are performed on a CRAY X/MP-48 for a model helicopter rotor in hover at various collective pitch angles. The results are compared with experimental data. Author

**A86-37939**
**EAP - FIGHTER BLUEPRINT**
G. WARWICK and T. HALL Flight International (ISSN 0015-3710), vol. 129, April 19, 1986, p. 25-30.

The EAP high-performance fighter aircraft, designed by Great Britain for flight this year, is described in detail. EAP is a single-seat delta-canard aircraft powered by two extended-reheat Turbo-Union RB. 199s. The design emphasis is on air-combat performance; attention is therefore focused on attained sustained turn rates and specific excess power. EAP represents a compromise between the design requirements of both beyond-visual-range and close-in combat. Pitch control is provided by the all-moving foreplane and wing trailing-edge flaperons programmed with airspeed and angle of attack. Roll control is provided by the flaperons which are fully spanned at moderate speed and inboard only at high speed. Since it is designed for angles of attack up to 30 degrees, the EAP has a chin (air) intake with a unique hinged lowerlip. Aside from this high-angle-of-attack, EAP is also capable of transonic acceleration, supersonic flight and short landing. One of the areas to be investigated is the reduction of aircraft infrared and radar cross-sections so as to escape early detection. It is concluded that the EAP is both fast-reacting and easily maneuverable. K.K.

**A86-38303**

**HAWK - THE BRITISH FIGHTING TRAINER**

K. G. HODSON (British Aerospace, PLC, Surrey, England) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 34 p.

(SAE PAPER 851768)

A development history is presented for the Hawk family of advanced jet trainer and attack aircraft, whose primary goals have been the achievement of low life cycle and acquisition costs, low fuel consumption, high reliability and structural integrity, and ease of maintenance and manufacture. Attention is given to design development program management lessons learned, the criteria used in choosing among alternative airframe configurations, and the weapons packages used by attack versions of the trainer. O.C.

**A86-38304**

**THE EMB-312 TUCANO - A BRAZILIAN TRAINER**

O. SILVA (Embraer-Empresa Brasileira de Aeronautica, S. A., Sao Jose dos Campos, Brazil) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 14 p.

(SAE PAPER 851769)

The design of the EMB-312 Tucano Brazilian advanced trainer is described. The high performance trainer is a low-wing monoplane with a single turboprop engine. The structure of the aircraft is a 2024 Al alloy stressed-skin type with wings and empennage in cantilever construction. The components and operation of the fuel, hydraulic, electrical and avionics systems of the trainer are examined. The advantages provided by the jetlike characteristics of the engine, single throttle lever, ejection seat, and staggered tandem cockpit seats of the trainer are discussed. The performance and fatigue life of the aircraft are evaluated; the trainer displays excellent aerobatic capabilities and a safe service-life of 6000 hours. I.F.

**A86-38307**

**X-WING - A LOW DISC-LOADING V/STOL FOR THE NAVY**

J. C. BIGGERS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and A. W. LINDEN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 17 p. refs

(SAE PAPER 851772)

The X-wing concept used in the design of the NASA/Army Rotor Systems Research Aircraft (RSRA) rotor wing is described. The X-wing VTOL concept uses a helicopter-like rotor system, but stops the rotor/wing in flight and uses it as the fixed wing. The major elements in the RSRA/X-wing project are the rotor/wing system, the fly-by-wire control system, the compressor supplying the Coanda blowing air, and the modifications to the RSRA drive train. The X-wing can provide one aircraft with fixed-wing cruise efficiency, helicopter-like hover efficiency and hover control power, 0 to 300-knot one-engine inoperative capability and acceptable empty weight/gross weight ratios. I.S.

**A86-38325*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LEADING-EDGE DESIGN FOR IMPROVED SPIN RESISTANCE OF WINGS INCORPORATING CONVENTIONAL AND ADVANCED AIRFOILS**

H. P. STOUGH, III, F. L. JORDAN, JR., D. J. DICARLO, and K. E. GLOVER (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 17 p. refs

(SAE PAPER 851816)

Discontinuous wing leading-edge droop designs have been evaluated as a means of modifying wing autorotative characteristics and thus improving airplane spin resistance. Addition of a discontinuous outboard wing leading-edge droop to three typical light airplanes having NACA 6-series wing sections produced significant improvements in stall characteristics and spin resistance. Wind tunnel tests of two wings having advanced natural laminar flow airfoil sections indicated that a discontinuous leading-edge droop can delay the onset of autorotation at high angles of attack without adversely affecting the development of laminar flow at cruise angles of attack. Author

**A86-38336*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE STOL PERFORMANCE OF A TWO-ENGINE, USB POWERED-LIFT AIRCRAFT WITH CROSS-SHAFTED FANS**

V. C. STEVENS, S. B. WILSON, III (NASA, Ames Research Center, Moffett Field, CA), and C. A. ZOLA (NASA, Lewis Research Center, Cleveland, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p.

(SAE PAPER 851839)

The short takeoff and landing capabilities that characterize the performance of powered-lift aircraft are dependent on engine thrust and are, therefore, severely affected by loss of an engine. This paper shows that the effects of engine loss on the short takeoff and landing performance of powered-lift aircraft can be effectively mitigated by cross-shafting the engine fans in a twin-engine configuration. Engine-out takeoff and landing performances are compared for three powered-lift aircraft configurations: one with four engines, one with two engines, and one with two engines in which the fans are cross-shafted. The results show that the engine-out takeoff and landing performance of the cross-shafted two-engine configuration is significantly better than that of the two-engine configuration without cross-shafting. Author

**A86-38337**

**REQUIREMENTS FOR FUTURE RALS/STOVL OPERATING CONCEPTS**

D. J. MCNALLY and D. M. BROWN (Northrop Corp., Aircraft Div., Hawthorne, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p.

(SAE PAPER 851840)

The particular application of the Remote Augmented Lift System (RALS) to tactical short take-off, vertical landing (STOVL) aircraft enables configurations to be designed that possess significant supersonic performance in addition to subsonic/transonic performance. Future tactical fighter aircraft for the 1995 time frame should be flexible enough to cover various roles, e.g., close air support (CAS)/battlefield air interdiction (BAI), and have significant air-to-air capability with rapid redeployment potential in the face of a changing battle scenario. In addition, these aircraft must possess superior lethality, survivability and availability characteristics. STOVL concepts make a distinct contribution to availability by virtue of allowing remote austere basing operations. Recent operational studies have identified new requirements for basing, support, and new technologies that could greatly improve sortie generation capability. This paper discusses requirements for a RALS/STOVL concept operating in this environment. Author

**A86-38338*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**THE IMPACT OF TECHNOLOGY ON FIGHTER AIRCRAFT REQUIREMENTS**

S. M. DOLLYHIGH and W. E. FOSS, JR. (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 10 p.
(SAE PAPER 851841)

Technology integration studies were made to examine the impact of emerging technologies on fighter aircraft. The technologies examined included advances in aerodynamics, controls, structures, propulsion, and systems and were those which appeared capable of being ready for application by the turn of the century. A primary impetus behind large increases in figher capability will be the rapid increase in fighter engine thrust-to-weight ratio. High thrust-weight engines, integrated with other advanced and emerging technologies, can result in small extremely maneuverable fighter aircraft that have thrust-weight ratios of 1.4+ and weight one-half as much as today's fighters. Future fighter aircraft requirements are likely to include a turn capability in excess of 7g's throughout much of the maneuver envelope, post-stall maneuverability, STOVL or VTOL, and a single engine for low cost. Author

**A86-38339*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ESTIMATION OF LIFT LOSSES OF HOVERING VEHICLES USING A SINGLE JET**

R. S. CHRISTIANSEN, L. K. MITCHELL, and J. E. ESHLEMAN (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p. refs
(SAE PAPER 851842)

This paper discusses the development of handbook techniques for the preliminary assessment of V/STOL aircraft performance while hovering in the proximity of the ground. In particular, the suckdown forces due to entrainment are described for configurations using a single jet. Corrections to current methods are suggested from an analysis of recent large-scale test data. Author

**A86-38340*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EFFECTS OF JET FLAP ON AV8-B 'HARRIER' PERFORMANCE**

A. S. HAHN and S. B. WILSON, III (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 45 p. refs
(SAE PAPER 851843)

This paper examines the effects of fitting various jet-flap configurations to an AV8-'Harrier II' Baseline aircraft using two NASA developed computer codes. The first code predicts the ground roll of an AV8-B with a partial span jet-flap, a full span jet-flap, a partial span internally blown-flap, and a full span internally blown-flap as well as the Baseline configuration. The second code used was a mission performance estimation routine called ACSYNT (Aircraft Synthesis). This code models each configuration on a standard mission so that the relative merits may be determined. Author

**A86-38341**

**FOLDING TILTROTOR TECHNOLOGY DEMONSTRATOR - THE NEXT STEP FOR TILTROTOR TECHNOLOGY**

D. P. GLEITER (Boeing Vertol Co., Philadelphia, PA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p. refs
(SAE PAPER 851844)

Based on a comparative study of competing V/STOL concepts, the folding tiltrotor offers many advantages for missions requiring long endurance combined with a speed capability in excess of 400 knots. Folding tiltrotor technology development began in 1967 and the results of wind tunnel tests and design studies show no significant technical obstacles to the development of a folding tiltrotor aircraft. The convertible fan/shaft CTFS-34 engine can be used to power a technology demonstrator aircraft. The next step in the development of tiltrotor technology should be a folding tiltrotor technology demonstrator based on either the V-22 or the S-3A. Author

**A86-38342**

**RESULTS OF PILOTED SIMULATION OF GRUMMAN DESIGN 698**

J. W. CLARK, JR., S. T. DONLEY, and J. B. JOHNS (U.S. Navy, Naval Air Development Center, Warminster, PA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 14 p.
(SAE PAPER 851846)

The third in a series of three piloted simulations of the Grumman Design 698 Tilt-Fan V/STOL Demonstrator was conducted at NASA Ames Research Center on the Vertical Motion Simulator. Both single-engine-failure characteristics (with and without engine cross-shafting) and hover/low-speed handling qualities were investigated. Based on minimum recovery speed, altitude loss, and ejection capability following a single engine failure, the cross-shafted configuration offers a substantial increase in flight safety over the non-cross-shafted configuration. Based on handling qualities ratings, touchdown performance, and pilot comments, attitude command/attitude hold or translational rate command/translational rate hold response type control systems yield satisfactory handling qualities during shipboard terminal operations. Author

**A86-38349*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HARRIER III-AV8B WITH A MODERN ENGINE**

S. B. WILSON, III (NASA, Ames Research Center, Moffett Field, CA) and J. M. WURTS (California Polytechnic State University, San Luis Obispo, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 14 p. refs
(SAE PAPER 851881)

The paper examines the application of a 26, 156-lb thrust engine (which is 30 percent more thrust than the short-lift dry rating on the F402-RR-406 Pegasus engine) to an AV-8B aircraft. This modern engine has 30 percent more thrust than the F402-RR-406 Pegasus engine with no increase in engine weight; the weight is assumed to be constant for both engines. The paper focuses on the benefit to the AV-8B in increasing short takeoff gross weight and vertical landing weight. A second comparison is made between the bigger engine with the existing thrust-versus-SFC curve, and a 10 percent lower SFC curve. The notion of a modern engine with 10 percent lower SFC and 30 percent more thrust for the same size and weight is presented as a hypothesis, and is not supported by discussing engine technology. There are no engine data or technical discussion as to how the modern engine is constructed or which manufacturer could build it. The performance estimates are generated by ACSYNT, a NASA developed computer code that is available to U.S. industry and has been reported on in a number of other publications. Author

**A86-38350**

**THE SIGNIFICANCE OF ADVANCED TECHNOLOGY ENGINES ON V/STOL SYSTEMS**

G. PERKINS (United Technologies Corp., Pratt and Whitney, East Hartford, CT) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p.
(SAE PAPER 851882)

An evaluation is made of the development status of next-generation engines offering improved specific thrust and fuel consumption for military V/STOL aircraft, with attention to the design configuration and advanced components technologies incorporated by the engines. Emerging engine technologies encompass metal matrix composites for fans, higher compressor stage loadings, digital control systems, carbon-carbon composite hot section components, and improved turbine blade cooling. Thrust/weight, specific excess power, takeoff gross weight, and life cycle cost trends are discussed. O.C.

**A86-38355**

**TRANSPORT AIRCRAFT CRASHWORTHINESS REQUIREMENTS - AN INDUSTRY VIEW**

W. W. BINGHAM (Boeing Commercial Airplane Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p.
(SAE PAPER 851888)

This paper reviews past design and operational achievements that minimize those conditions identified as prime in contributing to transport aircraft accidents. Recent history of survivable accidents is then examined to identify the critical sequences leading to the most frequent and/or serious accidents. Finally, existing and anticipated near-term advances in aircraft production technology that may eliminate the chain of events identified above as critical in accident scenarios are reviewed. Author

**A86-38362**

**A VERIFICATION OF PROPULSION AND AIRPLANE PERFORMANCE MODELS GENERATED FROM FLIGHT**

P. V. DONLAN (Kohlman Systems Research, Inc., Lawrence, KS) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p.
(SAE PAPER 851899)

Performance modeling is a process where a representative nominal engine model is calibrated to the test engines as installed on the test airplane. Research initiated by Schweikhard and Marshall at NASA and further developed at the University of Kansas has shown that performance modeling is a viable and inexpensive alternative to in-flight thrust measurements or calibrated engines. Testing using this method has been performed on twelve business jets. On one of these programs, both calibrated engines and a nominal engine model were available; thus verification of performance modeling was possible. Through this verification process it was shown that similar drag polars resulted from the two methods. A difference in drag was found to be no greater than 20 counts. This paper describes the methods used for the performance modeling, which includes propulsion modeling methods and flight test procedures. The resulting flight test data are presented. Author

**A86-38364**

**NONFLAMMABLE FLUID AND 8,000 PSI TECHNOLOGY FOR FUTURE AIRCRAFT HYDRAULIC SYSTEMS (22 CFR 125.4 /B/ /13/ APPLICABLE)**

K. E. BINNS, W. B. CAMPBELL (USAF, Wright-Patterson AFB, OH), N. J. PIERCE, and R. E. YOUNG (McDonnell Aircraft Co., St. Louis, MO) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 14 p.
(SAE PAPER 851909)

In the middle 1970s, the Air Force identified significant damage and losses due to noncombat hydraulic fluid fires. As a result of these fires, a search for a nonflammable hydraulic fluid for use in new aircraft was initiated. A nonflammable fluid, chlorotrifluoroethylene, was identified. However, its weight was over 2.2 times heavier than conventional fluid. This paper discusses the system design approaches, component design, and test results of an overall program to establish technology for use of this nonflammable fluid in new aircraft. This includes the tradeoff study results for selection of 8000 psi as the pressure level, design approaches to control water hammer pressures, component and system design and evaluation. The status of ongoing programs for investigating dynamic seals, pumps, and low energy consumption hydraulic concepts is also presented. Author

**A86-38365**

**LIGHTWEIGHT HYDRAULIC SYSTEM TECHNOLOGY - 8000 PSI UPDATE**

W. N. BICKEL (Rockwell International Corp., Columbus, OH) and J. OHLSON (U.S. Navy, Naval Air Development Center, Warminster, PA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 10 p.
(SAE PAPER 851910)

The use of higher operating pressures (8000 psi) in aircraft fluid systems is examined. The initial development, computer simulation, laboratory testing, and flight testing of the lightweight hydraulic system (LHS) are discussed. The compatibility testing and full-scale A-7E simulator evaluation of the actuators, actuator dynamic rod and piston seals, axial-piston pumps, titanium tubing, and servo valves of the full-scale LHS are described. The reliability, maintainability, and safety of the LHS are evaluated. Cost analysis of the system reveals that operating an aircraft with an 8000 LHS reduces the weight of the system by 30 percent and the volume by 40 percent as compared to the 3000 psi system. I.F.

**A86-38366**

**HYDRAULIC PUMPS FOR HIGH PRESSURE NON-FLAMMABLE FLUIDS**

J. A. HALAT (Vickers, Inc., Jackson, MS) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 11 p.
(SAE PAPER 851911)

Design considerations that 8000-psi and nonflammable fluids have upon an aircraft inline piston hydraulic pump are presented. The influence of the major physical properties of one nonflammable fluid, chlorotrifluoroethylene (CTFE), are discussed as well as the influence of the hydraulic system. Hydraulic pump pressure, based on experience with the U.S. Navy Lightweight Hydraulic System (LHS), can be increased to 8000 psi without encountering major problems. Utilization of CTFE as a hydraulic fluid shows considerable promise. The performance characteristics of an 8000-psi pump are presented. The paper includes a summary of high pressure operating experience. The paper concludes with a summary of the Wright Patterson Air Force Base Contract for three 40-gpm, 8000-psi CTFE pumps. Author

**A86-38367**

**8000 PSI HYDRAULIC SYSTEM SEALS AND MATERIALS TEST PROGRAM - A PROGRESS REPORT**

R. V. FLIPPO (HR Textron, Inc., Valencia, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 18 p.
(SAE PAPER 851913)

Flight control technology for 8000 psi has emerged almost simultaneously with new fire-resistant hydraulic fluids, such as MIL-H-83282 and chlorotrifluoroethylene. A proliferation of industry recommendations has resulted in a wide variety of mechanisms for solving associated actuator design problems, including tighter clearances, special seals, finishes, materials, and many others. As there are few common agreements on the issues, an extensive three-phase test program was undertaken to attempt to corroborate some of these approaches, or to suggest others that may be better or more cost effective. Author

**A86-38369**

**AIRCRAFT FLOTATION ANALYSIS - CURRENT METHODS AND PERSPECTIVE**

N. S. CURREY (Lockheed-Georgia Co., Marietta, GA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 13 p. refs
(SAE PAPER 851936)

Current methods of aircraft flotation analysis, i.e., analysis of an aircraft's ability to operate on an airfield surface of defined strength, are presented, together with the upcoming ICAO's ACN/PCN (aircraft classification number/pavement classification number) classification system. Flotation terminology and flotation parameters are defined. The Load Classification Number and the Load Classification Group methods of flotation analysis, adopted

in the past by the ICAO, are compared. Analysis methods recommended for military and for commercial usage are listed.
I.S.

**A86-38372*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**THE GENERATION OF TIRE CORNERING FORCES IN AIRCRAFT WITH A FREE-SWIVELING NOSE GEAR**
R. H. DAUGHERTY and S. M. STUBBS (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p. Previously announced in STAR as N86-11522. refs
(SAE PAPER 851939)

An experimental investigation was conducted to study the effect of various parameters on the cornering forces produced by a rolling aircraft tire installed on a tilted, free-swiveling nose gear. The parameters studied included tilt angle, trial, tire inflation pressure, rake angle, vertical load, and whether or not a twin tire configuration corotates. These parameters were evaluated by measuring the cornering force produced by an aircraft tire installed on the nose gear of a modified vehicle as it was towed slowly. Cornering force coefficient increased with increasing tilt angle. Increasing trial or rake angle decreased the magnitude of the cornering force coefficient. Tire inflation pressure had no effect on the cornering force coefficient. Increasing vertical load decreased the cornering force coefficient. When the tires of a twin tire system rotated independently, the cornering force coefficients were the same as those for the single-tire configuration. When the twin tire system was made to corotate, however, the cornering force coefficients increased significantly. Author

**A86-38373**
**EUROPEAN AIRCRAFT STEERING SYSTEMS**
D. W. S. YOUNG (Dowty Rotol, Ltd., Gloucester, England) and B. OHLY (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 16 p.
(SAE PAPER 851940)

The paper discusses system and hardware design characteristics of the steering for several current aircraft and aircraft under development, covering both mechanically and electronically controlled systems. Possible future developments for steering systems are discussed briefly. Author

**A86-38374**
**INTEGRATED BRAKING AND GROUND DIRECTIONAL CONTROL FOR TACTICAL AIRCRAFT**
K. L. SMITH, C. L. DYER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and S. M. WARREN (Boeing Military Airplane Co., Wichita, KS) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 16 p.
(SAE PAPER 851941)

An autonomous ground handling system is being developed that integrates and automatically controls selected aircraft functions, such as the rudder, brakes, and nose wheel steering, to prevent Air Force aircraft from veering off runways during adverse weather operations. The system uses only aircraft-generated signals and pilot inputs to control the lateral forces on the aircraft and keep it on the runway centerline. Piloted simulations of an F-4 equipped with the system indicate that it can extend the crosswind landing capability of the aircraft into a region designated 'unsafe' by the flight manual. Author

**A86-38375**
**THE HISTORY AND DEVELOPMENT OF THE REPEATABLE RELEASE CATAPULT HOLDBACK BAR**
J. D. HELM (Decoto Aircraft, Inc., Yakima, WA) and H. H. PERRY SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 24 p.
(SAE PAPER 851942)

A holdback and release device is generally used to restrain an aircraft prior to catapulting. For many years release was effected by rupture of a replaceable, frangible link in the release device. While this system is conceptually simple, it has many operational and logistic drawbacks. This paper describes the history and successful development of a reuseable, or repeatable release catapult holdback system as presently used on the F-14, F-18 and T-45. Author

**A86-38501**
**GENERAL AVIATION AIRCRAFT AERODYNAMICS; PROCEEDINGS OF THE GENERAL AVIATION AIRCRAFT MEETING AND EXPOSITION, WICHITA, KS, APRIL 16-19, 1985**
Meeting and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-621), 1985, 104 p. For individual items see A86-38502 to A86-38508.
(SAE SP-621)

The present conference considers propeller slipstream effects on a laminar wing boundary layer, the flight test evaluation of a laminar wing insect contamination protection system, experimental study results for a general aviation single-engine aircraft with natural flow wings, natural laminar boundary layer flow flight test experiment results, and the manufacturing tolerance requirements of laminar flow airframe surfaces. Also discussed are natural laminar flow conditions obtainable for regional commuter aircraft, the independence of parameters that are important to the design of subsonic canard-configured aircraft, analytical study results for three-surface lifting systems, and an application of the Carson (1982) cruise optimum airspeed compromise between speed and efficiency. O.C.

**A86-38504*** Wichita State Univ., Kans.
**FURTHER RESULTS OF NATURAL LAMINAR FLOW FLIGHT TEST EXPERIMENTS**
W. H. WENTZ, JR., A. AHMED (Wichita State University, KS), and R. NYENHUIS (Cessna Aircraft Co., Wichita, KS) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 37-50. refs
(Contract NAG1-104)
(SAE PAPER 850862)

Flight test experiments were conducted to measure the extent and nature of natural laminar flow on a smoothed test region of a swept-wing business jet wing. Surface hot film anemometry and sublimating chemicals were used for transition detection. Surface pressure distributions were measured using pressure belts. Engine noise was monitored by a microphone attached to the wing surface to study possible acoustic effects on stability of the laminar boundary layer. Side-slip conditions were flown to simulate changes in effective wing sweep. Flight instrumentation and ground data analysis techniques and a method for measuring intermittency of turbulence are described. Correlation was obtained between the hot film gage signals and chemicals for transition detection. Cross-flow vortices were observed for some flight conditions. Results of spectral and statistical analysis of the hot film signals for various flight test conditions are presented. Author

**A86-38506*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**INTERDEPENDENCE OF PARAMETERS IMPORTANT TO THE DESIGN OF SUBSONIC CANARD-CONFIGURED AIRCRAFT**
T. W. FEISTEL (NASA, Ames Research Center, Moffett Field, CA) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 73-83. refs
(SAE PAPER 850865)

An analysis is made of the interrelationship of the longitudinal parameters important to the aerodynamic design of an efficient canard or tandem wing configuration. It is shown that theoretical configuration span efficiencies substantially greater than one are feasible with the proper choice of parameters. This improvement can translate into significantly increased lift/drag ratios assuming fixed spans. The Prandtl-Munk relationship for induced drag is used as a convenient qualitative guide, with stability and trim criteria superimposed. An 'aspect-ratio ratio' parameter is introduced to aid in optimizing a configuration longitudinally. It is shown that a canard/wing 'aspect-ratio ratio' of approximately 3/2 to 2 is necessary to achieve peak span efficiency for a given span ratio and gap, assuming representative parameters. Author

**A86-38508**

### AN APPLICATION OF THE CARSON CRUISE OPTIMUM AIRSPEED - A COMPROMISE BETWEEN SPEED AND EFFICIENCY

H. C. SMITH (Pennsylvania State University, University Park) IN: General aviation aircraft aerodynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 95-99.

(SAE PAPER 850867)

It is well known that, for propeller-driven airplanes, maximum fuel economy occurs at maximum L/D ratio. It has been shown that, while the speed for maximum L/D yields the least fuel consumed per unit of distance, there is also a speed for the least fuel per unit of velocity, essentially, the best compromise between speed and fuel economy. This paper presents a simple method to predict this optimum airspeed in terms of calibrated airspeed. In this form, it is only a function of gross weight and could easily be made available in operating handbooks in the form of two-dimensional charts. It is shown that the optimum airspeeds for the range of normal operating gross weights requires fairly normal cruise power settings. The study further describes a simple, straightforward method of arriving at the relationship of cruise optimum airspeed in terms of maximum L/D speed. Author

**A86-38509**

### CRASH DYNAMICS OF GENERAL AVIATION AIRCRAFT; PROCEEDINGS OF THE GENERAL AVIATION AIRCRAFT MEETING AND EXPOSITION, WICHITA, KS, APRIL 16-19, 1985

Meeting and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-622), 1985, 108 p. For individual items see A86-38510 to A86-38514.

(SAE SP-622)

Papers are presented on formulating criteria to increase passenger safety survivability following small aircraft accidents. Consideration is given to the validation of the seat/occupant model for light aircraft, the development of criteria for general aviation seat and restraint system performance, and human response to impact acceleration. Topics discussed include procedures for evaluating aircraft crash floor pulses, crashworthy design considerations for the general aviation seat, design research for the Caravan 1 crew seat, and the development of mechanical components for advanced aircrew seating systems. I.F.

**A86-38513**

### A PROCEDURE TO EVALUATE AIRCRAFT CRASH FLOOR PULSES

G. WITTLIN (Lockheed-California Co., Burbank) IN: Crash dynamics of general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 55-63. refs

(SAE PAPER 850854)

The paper presents a rational method by which aircraft floor pulses can be defined and their effect on the seat-occupant system evaluated by using the pulses to obtain seat test performance data. The results of recent analyses of a transport airplane exposed to a candidate crash scenario along with seat test data are provided. The results of full-scale crash test analyses of general aviation aircraft are also addressed. It is shown that modeling of aircraft to obtain floor responses can produce a wide range of pulse definitions. It is not always obvious which pulse configuration may be more deleterious to the seat or occupant, without a procedure to compare seat-occupant response. Seat-occupant response evaluation requires that a set of test data and performance criteria parameters be established. Using an analytical approach correlated with test data, provides a basis for such an evaluation. A step-by-step procedure is evolved and comparisons of different pulses are illustrated. Author

**A86-38514**

### PRELIMINARY DESIGN RESEARCH FOR THE CARAVAN 1 CREW SEAT

R. K. RATHGEBER (FAA, Kansas City, KS) and P. E. PARKER (Cessna Aircraft Co., Wichita, KS) IN: Crash dynamics of general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 79-100. refs

(SAE PAPER 850856)

The Cessna Caravan 1 crew seat/restraint system incorporates many new design features. This system is the result of several iterations of development and evaluations using dynamic test procedures. The testing was done at the Protection and Survival Laboratory dynamic impact test track facility of the FAA Civil Aeromedical Institute. The recommendations of the General Aviation Safety Panel influeenced the test procedures and pass/fail criteria for this project. Data from the dynamic tests provided valuable information on features of seat/restraint system design. Author

**A86-38515**

### COMPOSITES: DESIGN AND MANUFACTURING FOR GENERAL AVIATION AIRCRAFT; PROCEEDINGS OF THE GENERAL AVIATION AIRCRAFT MEETING AND EXPOSITION, WICHITA, KS, APRIL 16-19, 1985

Meeting and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-623), 1985, 95 p. For individual items see A86-38516 to A86-38523.

(SAE SP-623)

The present conference on the design and manufacturing of general aviation aircraft composite structures considers the design and certification of a composite control surface, the application of photostress methods to study stress concentrations in composite structures, the buckling behavior and pertinent design data of laminated composite triangular plates, and stress concentrations at a rectangular cutout in a buffer strip laminate. Also discussed are the design and use of Kevlar reinforcements in aircraft structures, high producibility composites design, a room temperature-capable and high temperature-capable cementitious tooling and molding material, the use of an electroformed nickel mold for use in the manufacture of composite parts, the structural dynamics of electroimpulse deicing of a Kevlar-reinforced composite leading edge, and large amplitude vibrations of composite plates treated by self-generating functions. O.C.

**A86-38516**

### DESIGN AND CERTIFICATION OF A COMPOSITE CONTROL SURFACE

C. W. SCHNEIDER and D. C. GIBSON (Lockheed-Georgia Co., Marietta) IN: Composites: Design and manufacturing for general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1-8. refs

(SAE PAPER 850888)

The present graphite/epoxy composite rudder was designed, tested and certified to replace the G-III executive jet's conventional skin-stiffened aluminum structure, achieving a 50 percent increase in acoustic fatigue life with 22-percent weight savings. Full scale testing encompassed both static and flight tests. Attention is given to structural subelements' design details; an innovative rib cap design is employed to yield enhanced fatigue and damage resistance. O.C.

**A86-38520**

**DESIGN AND USE OF KEVLAR IN AIRCRAFT STRUCTURES**

P. R. LANGSTON (Du Pont de Nemours and Co., Textile Fibers Dept., Wilmington, DE) IN: Composites: Design and manufacturing for general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 41-55.

(SAE PAPER 850893)

Kevlar and Nomex can be applied in the design of aircraft primary structures to reduce weight, lower production costs and life cycle costs, reduce structural maintenance requirements, and increase reliability. Attention is given to Kevlar 49 reinforcing fibers; free vibration decay times, fatigue behavior, moisture absorption, honeycomb sandwich construction applications in conjunction with Nomex cores, and use in filament-wound solid laminates. Applications of these structural methods in A310 and B767 airliners, as well as general aviation, helicopter, and advanced military aircraft, are noted. O.C.

**A86-38701**

**TIME RUNS OUT FOR THE CLOCKWORK COCKPIT**

G. WARWICK Flight International (ISSN 0015-3710), vol. 129, April 26, 1986, p. 30-33.

The concept of an electronic cockpit began with the design of a CRT horizontal situation indicator for the 767, which led to an electronic attitude direction indicator, etc. Further integration and simplification of the displays permitted displacement of the flight engineer. Customer demands for the latest in technology spurred further cockpit automation, along with backup analog displays. Synoptic displays have been developed in order to extend the digital display formats, and retain their simplicity, from two-engine aircraft to four-engine aircraft such as the 747-400 under development. Similar upgrades are being introduced into the MD-80 series of aircraft, which will also carry wind shear alert capabilities. Additionally, the MD-88 will have either LCD or LED displays to replace electromechanical gages for engine instruments and fluids displays. Extensive upgrading of the redundant autopilot for the MD-11 will permit the aircraft to take corrective actions in the event of a malfunction. The success of the autopilot, and the basis for the decision to implement such an innovation, is a function of the long experience of the manufacturer with the aircraft. M.S.K.

**A86-38721#**

**AIRCRAFT WHEEL DESIGN AND PROVING**

S. M. SMITH (Dunlop Aerospace Group, Coventry, England) Tech Air (ISSN 0040-0831), vol. 44, May 1986, p. 1-4.

The critical design parameters of A-frame and bowl-type wheel designs for aircraft landing gear are summarized. Only the bowl-type design permits installation of heavier brakes, at a concommitant weight penalty, for absorption of higher energy loads. Attention is given to stress-strain prediction for the wheel flange which retains the tire, noting that the possibility of multiple wheel failures on modern transport aircraft has led to the requirement that the wheel rim must be capable of bearing the full load of the aircraft. The necessity of regular tire inspections to detect incipient failure conditions is stressed, along with the inclusion of a fusible device in the tires to prevent blowouts by deflating the tires in the event of overheating or overused brakes. Techniques of photostress analysis of the main wheel diaphragms are described, along with factors influencing the design of the bolt/half hub interface. Titanium and aluminum lithium alloys are noted as potential high-strength, lower-weight materials for wheels to replace magnesium and cast aluminum. Finally, tire testing procedures to ensure that tires meet the specified performance parameters are outlined. M.S.K.

**A86-38836*#** PRC Kentron, Inc., Hampton, Va.

**STRUCTURAL ANALYSIS OF THE CONTROLLED IMPACT DEMONSTRATION OF A JET TRANSPORT AIRPLANE**

E. L. FASANELLA (PRC Kentron, Inc., Hampton, VA), E. WIDMAYER (Boeing Commercial Airplane Co., Seattle, WA), and M. P. ROBINSON (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 324-332. refs

(AIAA PAPER 86-0939)

An analytical method has been developed for assessing crash dynamics of large transport aircraft, such as in the NASA Controlled Impact Demonstration (CID) jet crash test on December 1, 1984. The DYCAST nonlinear finite-element computer code was used in a series of progressively more difficult tasks to model complete transport aircraft crashes. Single aircraft frames and fuselage section vertical drop tests were modeled and analyzed to obtain comparisons with experimental data and to develop hybrid element crash springs for use in the large CID model. Predictions of crash and acceleration levels from a symmetric CID model agreed well with data from the CID experiment. I.S.

**A86-38837*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EQUIVALENT PLATE ANALYSIS OF AIRCRAFT WING BOX STRUCTURES WITH GENERAL PLANFORM GEOMETRY**

G. L. GILES (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 333-342. refs

(AIAA PAPER 86-0940)

A new equivalent plate analysis formulation is described which is capable of modeling aircraft wing structures with a general planform such as cranked wing boxes. Multiple trapezoidal segments are used to represent such planforms. A Ritz solution technique is used in conjunction with global displacement functions which encompass all the segments. This Ritz solution procedure is implemented efficiently into a computer program so that it can be used by rigorous optimization algorithms for application in early preliminary design. A direct method to interface this structural analysis procedure with aerodynamic programs for use in aeroelastic calculations is described. This equivalent plate analysis procedure is used to calculate the static deflections and stresses and vibration frequencies and modes of an example wing configuration. The numerical results are compared with results from a finite element model of the same configuration to illustrate typical levels of accuracy and computation times resulting from use of this procedure. Author

**A86-38840#**

**OPERATIONAL EXPERIENCE OF U.S. AIR FORCE WITH STRUCTURAL COMPOSITES**

T. F. CHRISTIAN, JR., M. K. STOWERS, W. H. SCHWEINBERG, and G. W. OYLER (USAF, Warner Robins Air Logistics Center, Robins AFB, GA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 362-365.

(AIAA PAPER 86-0946)

USAF operational experience with composites as primary structures in fighter, transport, and trainer aircraft is described. The advantages and the problems of maintenance of each structure are discussed. The items discussed include the structures and parts made of boron-epoxy and graphite/epoxy laminates, used as skins in the F-15 and F-16, respectively; graphite/fiberglass monolithic leading wing edges and graphite/epoxy/Kevlar skins in C-141; graphite/epoxy wing tip, aileron trailing edge wedge, main landing gear strut door, and wing rib in T-38; and Kevlar/epoxy skins and intercostals, and graphite-reinforced belly skin panel in C-130. The problems associated with nondestructive inspection and with the effects of moisture were of particular concern in obtaining consistent repairs. I.S.

**A86-38846#**

### INFLUENCE OF FBW - CONTROL LAWS ON STRUCTURAL DESIGN OF MODERN TRANSPORT AIRCRAFT

M. BESCH (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 409-420. refs
(AIAA PAPER 86-0953)

The influence of such novel aircraft features as control laws is discussed in the context of an implementation of fly-by-wire and sidestick controller technologies satisfying the FAR/JAR 25.331 Vertical Design Maneuver Requirements. Attention is given to the possibility that pilot-induced oscillation associated with the sidestick controller will lead to horizontal tailplane overloading, in light of study results which compare conventional and control law-incorporating aircraft which employ sidestick controls. O.C.

**A86-38851#**

### EXPERIMENTAL AEROELASTIC BEHAVIOR OF FORWARD SWEPT GRAPHITE/EPOXY WINGS WITH RIGID BODY FREEDOMS

G.-S. CHEN and J. DUGUNDJI (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 462-471. refs
(Contract F49620-85-C-0099)
(AIAA PAPER 86-0971)

An analytical and experimental investigation was made of the aeroelastic flutter and divergence behavior of graphite/epoxy forward swept wings with rigid body pitch and plunge freedoms present. A complete, two-sided 30-degree forward swept wing aircraft model was constructed and mounted with low friction bearings in a low speed wind tunnel. Four different ply layup wings could be interchanged on the model, namely, (0 2/90)s, (15 2/0)s, (30 2/0)s, and (-15 2/0)s. Wind tunnel tests of the 'free' flying models revealed body freedom flutter, bending-torsion flutter, and a support dynamic instability which could be eliminated by proper adjustment of the support stiffness. Good agreement with linear theory was found for all the observed instabilities. Additional tests on the models with rigid body pitch only gave lower critical speeds, while tests on the cantilever wings gave higher speeds. The (15 2/0)s wing gave the best tailored aeroelastic behavior. Author

**A86-38861#**

### A STUDY OF CRACKING IN THE PRESSURE BULKHEAD OF A MILITARY TRANSPORT AIRCRAFT

D. R. SHOWERS, T. F. CHRISTIAN, JR., and D. O. HAMMOND, JR. (USAF, Warner Robins Air Logistics Center, Robins AFB, GA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 579-584.
(AIAA PAPER 86-0983)

This paper presents an investigation into aft fuselage pressure bulkhead cracking experience by some U.S. Air Force C-141B military transport aircraft during operational service. Following force wide inspection, an extensive finite element modeling effort was conducted to ascertain the stresses present in the bulkhead which caused the cracking. Following this assessment, an evaluation of potential repairs and modifications was also conducted using finite modeling techniques. This paper points out the fact that detailed studies of fuselage structure now are becoming necessary since military aircraft are remaining in operational inventories longer. This means that the gradual accumulation of pressure cycle damage is now becoming apparent, however, well established analysis techniques which have been used for years to evaluate wing structure are quite adequate for this task. All that is required is that attention be paid to fuselage pressure structure as has been done in the past wing and empennage structure. Author

**A86-38865#**

### GENERIC AIRCRAFT GROUND OPERATION SIMULATION

W. S. PI, J. R. YAMANE, and M. J. C. SMITH (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 606-619. refs
(Contract F33615-82-C-3216)
(AIAA PAPER 86-0989)

A generic aircraft ground operation simulation code was developed under an Air Force contract to provide rapid assessment of the structural capabilities of aircraft under various operating modes and surface conditions. The code is capable of predicting the response of aircraft while performing touchdown, taxiing, turning, and braking operations on paved, paved/bomb-damaged repaired, and unpaved yielding soil-surface runways. Analytical models were established for the airframe structure, the landing gear wheel assembly, and various types of landing gears including the cantilever axle, articulated, and fully levered types. Applying the new simulation code, the predicted ground operation results of C-141B, C-130, F-16, and F-4E aircraft correlated favorably with the test data acquired in the Air Force 'HAVE BOUNCE' program. Author

**A86-38869#**

### A UNIFIED PROCEDURE FOR MEETING POWER-SPECTRAL-DENSITY AND STATISTICAL-DISCRETE-GUST REQUIREMENTS FOR FLIGHT IN TURBULENCE

J. G. JONES (Royal Aircraft Establishment, Farnborough, England) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 646-652. refs
(AIAA PAPER 86-1011)

The relationship between the power-spectral-density (PSD) and statistical-discrete-gust (SDG) approaches to the analysis and prediction of aircraft response to atmospheric gusts and turbulence is examined in the light of recent studies. In particular, it has been shown that the PSD method can be reformulated and implemented as a variational problem in which the aircraft response is evaluated on the basis of a worst-case analysis to find the associated tuned input pattern, as in the SDG approach. It is thus possible to relate each of the two methods to a common approach in the form of a statistical pattern theory, pointing the way to a possible unified gust specification. V.L.

**A86-38893#**

### REVIEW OF DYNAMIC INFLOW MODELING FOR ROTORCRAFT FLIGHT DYNAMICS

G. H. GAONKAR (Florida Atlantic University, Boca Raton) and D. A. PETERS (Georgia Institute of Technology, Atlanta) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 89-115. refs
(Contract DAAG29-85-K-0228)
(AIAA PAPER 86-0845)

Dynamic inflow and its influence on some problems of rotorcraft flight dynamics are briefly introduced under transient conditions, as required in flight dynamics. The bases of modeling range from a simple empirical formulation to an involved prescribed-wake, discrete-vortex analysis of a four-bladed rotor. The emphasis is on perturbed linear versions of inflow in matrix form and on the sensitivity of low-frequency stability and response to inflow. However, non-linear versions for use in time-history solutions are presented. Coverage also includes the areas of weakness, controversial notions, and the need for additional test data on rotor-body damping in forward flight for a better appreciation of the developments in modeling dynamic inflow. Author

**A86-38902*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**APPLICATION OF THE UNSTEADY VORTEX-LATTICE METHOD TO THE NONLINEAR TWO-DEGREE-OF-FREEDOM AEROELASTIC EQUATIONS**

T. W. STRGANAC (NASA, Langley Research Center, Hampton, VA) and D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 201-210. refs
(AIAA PAPER 86-0867)

A means of numerically simulating flutter is established by implementing a predictor-corrector algorithm to solve the equations of motion. Aerodynamic loads are provided by the unsteady vortex lattice method (UVLM). This method is illustrated via the obtainment of stable and unstable responses to initial disturbances in the case of two-degree-of-freedom motion. It was found that for some angles of attack and dynamic pressure, the initial disturbance decays, for others it grows (flutter). When flutter occurs, the solution yields the amplitude and period of the resulting limit cycle. The preliminaray results attest to the feasibility of this method for studying flutter in cases that would be difficult to treat using a classical approach. K.K.

**A86-38910#**

**EFFECTS OF STRUCTURAL NONLINEARITIES ON LIMIT CYCLE RESPONSE OF AERODYNAMIC SURFACES**

R. M. LAURENSON, A. J. HAUENSTEIN, J. L. GUBSER (McDonnell Douglas Astronautics Co., St. Louis, MO), and R. P. BRILEY (Harris Corp., Melbourne, FL) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 279-292. refs
(Contract F49620-82-C-0043; F49620-84-C-0123)
(AIAA PAPER 86-0899)

An asymptotic expansion approximation technique, developed to predict limit cycle oscillation response for aerodynamic surfaces with discrete structural nonlinearities, is presented. To evaluate the adequacy of this technique, numerical simulation results are employed. Several numerical integration techniques are evaluated on a comparative basis for predicting the limit cycle response of the nonlinear system. Results obtained during this study show that: (1) the use of asymptotic expansion methods improves the prediction of aerodynamics surface limit response; (2) the Runge-Kutta, Shanks, and Adams-Moulton simulation techniques are all appropriate for this class of problems; (3) aerodynamic surfaces with structural nonlinearities are susceptible to limit cycle behavior at dynamic pressures below the linear flutter values; (4) the limit cycle respones is characterized as a constant amplitude motion which is a function of the magnitude of the nonlinearity and the dynamic pressure. K.K.

**A86-38931#**

**USE OF THE FLIGHT SIMULATOR IN PERFORMING AFTI/F-16 AIRPLANE AEROSERVOELASTIC ANALYSIS**

M. G. ALLEN, M. S. REARDON, and F. W. GORDON (General Dynamics Corp., Fort Worth, TX) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 493-502. Research supported by General Dynamics Corp. and USAF. refs
(AIAA PAPER 86-0957)

Aeroservoelastic analysis of the AFTI/F-16 airplane for the Automated Maneuvering Attack System Phase has been accomplished by using the dedicated flight simulator. Flexible airframe effects were added, externally generated random noise was applied to a selected control surface loop, and the noise and simulator system response were recorded and monitored with a small independent computer. The response was Fourier transformed, plotted, and margins were obtained. The approach avoided the complexities of mathematically modeling and analyzing non-integer multi-rate digital systems because these systems form a part of the simulator. The approach was possible because digital system technology has provided appropriate computing capacity at reasonable cost. Author

**A86-38947#**

**ACCURATE DYNAMIC THEORY FOR SUPERMANEUVERABLE AIRCRAFT WINGS**

G. A. OYIBO (Fairchild Republic Co., Farmingdale, NY) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 664-671. refs
(Contract F49620-85-C-0090)
(AIAA PAPER 86-1006)

Some dynamic theories that can be used to understand the aeroelastic tailoring mechanism are reviewed. In particular, the accuracy of the St. Venant torsion theory, that is frequently used in aeroelastic analysis, is examined with reference to the effects of the wing aspect ratio and other design parameters. It is shown that ignoring warping arbitrarily using St. Venant's theory can result in errors over 80 percent in analytical results for composite (supermaneuverable) aircraft wings. Accurate modeling of the warping phenomenon is shown to be particularly important for wings with coupling and higher vibration modes. V.L.

**A86-38950#**

**FLUTTER OF WINGS WITH LEADING EDGE CONTROL SURFACES**

R. YURKOVICH (McDonnell Aircraft Co., Saint Louis, MO) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 693-700. refs
(Contract N00019-75-C-0424)
(AIAA PAPER 86-0897)

During the development of the F/A-18 aircraft, aeroelastic analyses were conducted to determine the flutter and divergence characteristics of the aircraft. These analyses indicated that the flutter and divergence speeds of the clean wing are highly dependent on the rotational stiffness of the leading edge flaps. It was found that the leading edge flap divergence is responsible for a body freedom flutter which is similar to that seen with a forward swept wing. Several methods of including the leading edge flaps in the flutter and vibration analyses were investigated. Finally, the analytical results were confirmed by flutter model testing. Author

**A86-38952*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CRASH ENERGY ABSORBING COMPOSITE SUB-FLOOR STRUCTURE**

G. L. FARLEY (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986. 10 p. refs
(AIAA PAPER 86-0944)

Static crushing tests were conducted on four different beam concepts; honeycomb sandwich, sine-wave and two integrally stiffened designs. The sine-wave beams, depending upon specimen geometry, has the highest energy absorption potential of the four concepts evaluated. All beam designs produced a progressive crushing mode similar to tube specimens. The energy absorption capability of sine-wave beam specimens were predictable from results of circular cross section tubes. A comparison of energy absorption capability was made between integrally stiffened beams fabricated from graphite/epoxy, Kevlar-49/epoxy and aluminum. The energy absorption capability of the graphite/epoxy integrally stiffened beams exceeded both the Kevlar-49/epoxy and aluminum integrally stiffened beams. The energy absorption potential of composite structures is between five and ten times that of comparable metallic structure. Author

**A86-39564#**

**RESEARCH ON THE TECHNOLOGY OF AN AIRPLANE CONCEPT FOR A STATIONARY HIGH-ALTITUDE RELAY PLATFORM (SHARP)**

J. DELAURIER, B. GAGNON, J. WONG, R. WILLIAMS, and C. HAYBALL (Toronto, University, Canada) (CASI, Annual General Meeting, 32nd, Montreal, Canada, May 27, 28, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 5-22. Research supported by the Canadian Department of Communications. refs

A summary is presented of research carried out by the University of Toronto Institute of Aerospace Studies on an aeronautical Stationary High Altitude Relay Platform (SHARP) for telecommunication relay functions. The design goal is a platform that can fly in stationkeeping mode for up to 1 yr at 21 km altitude. The machine requires an automatic flight controller which can respond to atmospheric disturbances with minimum propulsive energy consumption, besides carrying the microwave relay equipment. Studies thus far, including the construction of prototypes, have identified an aircraft with an oversize stabilizer onto which is mounted a lightweight rectenna. A transmitter on the ground can then beam energy to drive the propeller-driven aircraft, which will also carry the relay equipment. Various design alternatives and techniques explored to lower weight and the required engine power, obtain an aerodynamic configuration suitable for stable flight in climb and loiter, and to define an optimized flight profile are described. Test results with prototype SHARP vehicles are provided and discussed in terms of future research directions. M.S.K.

**A86-39565#**

**LOW AIRSPEED ENVELOPE DETERMINATION OF THE CH-139 JET RANGER HELICOPTER**

W. R. JUPP (Department of National Defence, Ottawa, Canada) (CASI, Helicopter Symposium, Montreal, Canada, May 28, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 23-33.

The results of engineering trials to determine the low-speed relative-wind limits of the Jet Ranger CH-139 helicopter for training purposes are reported. The low-speed performance was evaluated as a function of the longitudinal center of gravity (CG) and the gross weight (GW), ranging from 107-2300 in. and 2300-2800 lb, respectively. Trials were carried out in hover at wind speeds up to 30 kt. Instrumentation was installed for recording the rotor flap angle, heading, longitudinal and lateral control, fuel consumption and collective position control. The results indicated that the flight envelope is acceptable for training missions. The tests also revealed the worth of monitoring the rotor flapping angle for determining the flight envelope of teetering rotor helicopters. M.S.K.

**A86-39597*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**RECENT DEVELOPMENTS IN THE DYNAMICS OF ADVANCED ROTOR SYSTEMS. I**

W. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) Vertica (ISSN 0360-5450), vol. 10, no. 1, 1986, p. 73-107. Previously announced in STAR as N85-24320. refs

The problems that were encountered in the dynamics of advanced rotor systems are described. The methods for analyzing these problems are discussed, as are past solutions of the problems. To begin, the basic dynamic problems of rotors are discussed: aeroelastic stability, rotor and airframe loads, and aircraft vibration. Next, advanced topics that are the subject of current research are described: vibration control, dynamic upflow, finite element analyses, and composite materials. Finally, the dynamics of various rotorcraft configurations are considered: hingeless rotors, bearingless rotors, rotors with circulation control, coupled rotor/engine dynamics, articulated rotors, and tilting proprotor aircraft. Author

**A86-39763#**

**SIX-FORCE-FACTOR IDENTIFICATION OF HELICOPTERS**

J. ZHANG (Xian Jiaotong University, Xian, People's Republic of China) and W. LI (Flight Test Research Centre of China, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, April 1986, p. 139-147. In Chinese, with abstract in English. refs

Applied loads are calculated using motion equations and measured data of the system's motion parameters. The basic theory for a frequency response function method in load identifications is presented, and the use of random loads for load identification is discussed. The three main aspects involved in the six-force-factor identification of helicopters are described in detail. These are: (1) ground calibration, (2) the measurement of structural response in flight, and (3) the calculation of the six-force-factor. It is noted that dynamic load, static load and fatique test data can be obtained simultaneously. It is concluded that the six-force-factor of helicopters was identified successfully, and that the data obtained can be instrumental in helicopter design. K.K.

**N86-26320#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Human Engineering Div.

**SOME QUANTITATIVE METHODOLOGY FOR COCKPIT DESIGN**

C. BATES, JR. and M. M. VIKMANIA *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 10 p Oct. 1985 refs

Avail: NTIS HC A07/MF A01

The rapidly developing technology in sensor systems, microprocessors, artificial intelligence and communication systems has blurred the traditional lines between avionics subsystems and offers new design options for integrating the aircrew into the weapon system. These developments, together with the stressful flight regimes imposed by advanced threat systems and the night-in-weather environment required for survival in air-to-ground attack/interdiction, require new approaches to crew station design. These new design opportunities are limited only by the design tools and data bases available for their execution. A simplified cockpit design process can be summarized as conceptual design, detailed design, and design verification. With the many tools needed to pursue this process the subset involving man/machine interface must provide a decision track quantifying and predicting the impact of design decisions on crew performance. To meet the objective of the full utilization of the weapon system crew, each technology option under consideration for incorporation in the cockpit must be judged with consideration of both mission and human performance. The cockpit design process must be embedded in an adequate human performance data base tailored for use by design personnel and must take full advantage of operational experience. The development of a family of cockpit design tools, together with the required data bases, has been one of the objectives of the Air Force Aerospace Medical Research Laboratory research program. From this program a select set of methods will be described and examples provided. Author

**N86-26328*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**X-29A TECHNOLOGY DEMONSTRATOR FLIGHT TEST PROGRAM OVERVIEW**

W. J. SEFIC and C. M. MAXWELL May 1986 17 p refs Presented at the ISA Aerospace Industries/Test Measurement Symposium, Seattle, Wash., 5-8 May 1986

(NASA-TM-86809; H-1347; NAS 1.15:86809; ISA-504) Avail: NTIS HC A02/MF A01 CSCL 01C

An overview of the X-29A functional flight program and concept evaluation program is presented, including some of the unique and different preparations for the first flight. Included are a discussion of the many organizational responsibilities and a description of the program management structure for the test team. Also discussed are preflight ground, flight functional envelope expansion, and flight research test objectives and qualitive results to date for both a limited-envelope flight control system and an expanded-envelope system. The aircraft, including the instrumentation system and measurements, is described. In addition, a discussion is included regarding the use of major support facilities, such as ground and flight simulators, the NASA Western Aeronautical Test Range and mission control center, and the Grumman automated telemetry station. An overview of the associated real-time and postflight batch data processing software approaches is presented. The use of hardware-in-the-loop simulation for independent verification and validation and mission planning and practice is discussed. Also included is a description of the flight-readiness review, the airworthiness and flight safety review, work scheduling, technical briefings, and preflight and postflight crew briefings. The configuration control process used on the X-29A program is described, and its relationship to both simulation and aircraft operations is discussed. An X-29A schedule overview is presented with an outline of a proposed follow-on program. Author

**N86-26329#** Federal Aviation Administration, Washington, D.C.
**FLIGHT TEST GUIDE FOR CERTIFICATION OF TRANSPORT CATEGORY AIRPLANES**
9 Apr. 1986 96 p
(FAA-AC-25-7) Avail: NTIS HC A05/MF A01

These flight test requirement guidelines provide an acceptable means of demonstrating compliance with the applicable airworthiness requirements. Controllability and maneuverability; stability; stalls; ground and water handling characteristics; vibration and buffeting; high speed performance; takeoff and landing; weight and load distribution limits; and propeller speed and pitch limits are discussed. B.G.

**N86-26331*#** Textron Bell Helicopter, Fort Worth, Tex.
**SIX DEGREE-OF-FREEDOM LIVE ISOLATION SYSTEMS, PART 1 Interim Report**
D. R. HALWES and C. O. NICKS Apr. 1986 79 p
(Contract NAS1-16969)
(NASA-CR-177928; NAS 1.26:177928) Avail: NTIS HC A05/MF A01 CSCL 01C

A Total Main Rotor Isolation System (TRIS) was analyzed, designed, fabricated, and bench tested for the reduction of main rotor vibration levels transmitted to the helicopter fuselage. The TRIS consists of a six degree-of-freedom passive system using six Liquid Inertia Vibration Eliminator (LIVE) units developed by Bell Helicopter Textron. The objective of the program is to develop a helicopter isolation system that will achieve 90% (or greater) isolation at minimum weight with no degradation in vehicle stability, handling qualities, alignment tolerance, and reliability or maintainability. Author

**N86-26332#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**AIRCRAFT NUCLEAR SURVIVABILITY METHODS Ph.D. Thesis**
H. A. UNDEM Sep. 1985 279 p
(AD-A163218; AFIT/DS/PH/84-3) Avail: NTIS HC A13/MF A01 CSCL 18C

A new approach for assessing the survivability of aircraft components in nuclear blast and thermal environments is presented in this dissertation. A nonparametric technique is developed for use in calculating the reliability interference integral. This approach eliminates the need for density function identification and parameter estimation. Furthermore, the method can be used without resorting to large-sample random Monte Carlo simulation or propagation of moments. In addition to this, the derived cumulative distribution function using such a technique exactly interpolates the true distribution function at selected points. The method is applied to the problem of aircraft survivability in nuclear blast environments using failure (strength) distributions found in the literature. It is also applied to the case of aircraft survivability in nuclear thermal environments where direct failure data is not available. Inputs to the engineering models involved are treated statistically and the method is used to rigorously determine the statistical nature of the output variables. GRA

**N86-26334#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
**AIRCRAFT PERFORMANCE OPTIMIZATION WITH THRUST VECTOR CONTROL M.S. Thesis**
M. S. FELLOWS Dec. 1985 132 p
(AD-A165388; AFIT/GAE/AA/85D-6) Avail: NTIS HC A07/MF A01 CSCL 01B

The objective of this thesis is to determine to what extent a highly-maneuverable aircraft's overall performance capability is enhanced by thrust-vectoring nozzles. The resulting performance capabilities are compared to a baseline configuration with non-thrust-vectoring nozzles to determine the effects and advantages of thrust vectoring. The results indicate that the use of vectored thrust can significantly increase an aircraft's performance capability in turning flight. The greater the demand on the aircraft in a turning combat scenario, the more the aircraft utilizes its thrust-vectoring capability to complete the task. The results also indicate that the use of vectored thrust in other phases of flight -- such as cruise, acceleration and climb -- only slightly increases an aircraft's performance capability. GRA

**N86-27277#** National Aerospace Lab., Tokyo (Japan).
**AN ANALYSIS OF THE LIMIT CYCLE OBSERVED IN THE FUNCTIONAL MOCKUP TEST OF THE NAL QSTOL RESEARCH AIRCRAFT**
H. YAMATO, T. UCHIDA, N. OKADA, T. OGAWA, and A. TADA Dec. 1985 56 p In JAPANESE; ENGLISH summary
(NAL-TR-893; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

The quiet STOL research aircraft under development at the National Aerospace Laboratory is equipped with the Stability and Control Augmentation System (SCAS). When the SCAS Pitch CWS mode is engaged in flight simulation tests using the control system functional mockup, a small limit cycle is observed. The method of describing functions is used to analyze this problem, because nonlinearities in the mechanical linkages and the power actuator play an important role in sustaining the limit cycle. To construct a mathematical model of the control system, nonlinear elements are employed so that the model response may accord with functional mockup test results including the frequency response. Through both the test and the analysis, it is shown that the present method is an effective tool for analyzing the limit cycle. And it is also clarified that the limit cycle observed is not so annoying to the pilot and is within the limits of the MIL specifications for sustained oscillations. Author

**N86-27278*#** PRC Kentron, Inc., Hampton, Va.
**EFFECT OF EMERGING TECHNOLOGY ON A CONVERTIBLE, BUSINESS/INTERCEPTOR, SUPERSONIC-CRUISE JET**
F. L. BEISSNER, JR., W. A. LOVELL, A. W. ROBINS, and E. E. SWANSON May 1986 60 p
(Contract NAS1-18000)
(NASA-CR-178097; NAS 1.26:178097) Avail: NTIS HC A04/MF A01 CSCL 01C

This study was initiated to assess the feasibility of an eight-passenger, supersonic-cruise long range business jet aircraft that could be converted into a military missile carrying interceptor. The baseline passenger version has a flight crew of two with cabin space for four rows of two passenger seats plus baggage and lavatory room in the aft cabin. The ramp weight is 61,600 pounds with an internal fuel capacity of 30,904 pounds. Utilizing an improved version of a current technology low-bypass ratio turbofan engine, range is 3,622 nautical miles at Mach 2.0 cruise and standard day operating conditions. Balanced field takeoff distance is 6,600 feet and landing distance is 5,170 feet at 44,737 pounds. The passenger section from aft of the flight crew station to the aft pressure bulkhead in the cabin was modified for the interceptor version. Bomb bay type doors were added and volume is sufficient for four advanced air-to-air missiles mounted on a rotary launcher. Missile volume was based on a Phoenix type missile with a weight of 910 pounds per missile for a total payload weight of 3,640 pounds. Structural and equipment weights were adjusted and result in a ramp weight of 63,246 pounds with a fuel load of 30,938 pounds. Based on a typical intercept mission flight profile, the resulting radius is 1,609 nautical miles at a cruise Mach number of 2.0. Author

**N86-27279*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DIVERGENCE STUDY OF A HIGH-ASPECT RATIO, FORWARD-SWEPT WING**

S. R. COLE Jun. 1986 10 p Presented at the AIAA 24th Aerospace Sciences Meeting, Reno, Nev., 6-9 Jan. 1986 Previously announced in IAA as A86-19632

(NASA-TM-87682; NAS 1.26:87682) Avail: NTIS HC A02/MF A01 CSCL 01C

An experimental wind-tunnel study to determine the divergence characteristics of a high-aspect ratio, forward-swept wing has been conducted in the NASA Langley Research Center (LaRC) Transonic Dynamics Tunnel (TDT). The rectangular wing used for this study had a panel aspect ratio of 9.16 (lambda = 0 deg.) and the sweep angle could be set at lambda = 0 deg., -15 deg., -30 deg., -45 deg., or -60 deg. A rectangular wing tip shape was tested at each of these sweep angles. In addition, a tip shape parallel to the freestream flow was tested for a wing sweep angle of lambda = -45 deg. The root of the wing was cantilever mounted to the wall of the wind tunnel. Divergence conditions were measured at M = 0.4 for each sweep angle and tip configuration tested. Subcritical response techniques were used to extrapolate to the divergence conditions during the wind-tunnel test. The primary objective of this test was to obtain data which could be used to verify for this configuration the divergence prediction capability of an aeroelastic analysis code. Subsonic lifting surface theory (kernel function) aerodynamics are utilized by this particular code. The analytical predictions of divergence were found to be significantly conservative at all forward sweep angles. At lambda = -45 deg., the analysis was 14 percent conservative. The effect of the two tip shapes on the divergence dynamic pressure was predicted accurately by the analysis. The divergence condition for the tip shape parallel to the flow occurred at a dynamic pressure 14 percent higher than the divergence condition with a rectangular tip shape. Author

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-37193**

**PUTTING HUMANS INTO VIRTUAL SPACE**

T. A. FURNESS, III and D. F. KOCIAN (USAF, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 214-230. refs

Existing computer displays fail to communicate effectively spatial information to humans in a number of piloting, command, control, communication and design applications. These interfaces are further limited by unnatural operator input modes. To solve these problems the concept of a virtual crew station is introduced which is implemented by visual and auditory virtual displays and natural psychomotor controls including voice, head, eye and hand controllers. A virtual space simulator called the Visually-Coupled Airborne Systems Simulator (VCASS) is described. Experimental findings using the VCASS are related, demonstrating the utility, performance and areas of improvement needed for virtual interfaces. Future applications of a virtual terminal are also discussed. Author

**A86-37333**

**A THERMAL IMAGING PAYLOAD FOR RPV APPLICATIONS**

W. T. MOORE and T. D. WOOLLS (Rank Pullin Controls, Ltd., Leicester, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 14.1-14.10. Research supported by the Royal Signals and Radar Establishment.

Attention is given to the design process considerations, adopted features, and prospective performance of an RPV-carried thermal IR imaging payload. The present design employs coaxial polygon optics, whose scan mechanism, corresponding to a 7-cm cube, can provide high performance with 448 lines. Attention is given to such system features as the automation of imager controls, the cryogenic cooling system, the wide angle telescope, and the video channel downlink to a ground station. O.C.

**A86-37341**

**THERMAL ZOOM OPTICS FOR R.P.V. SENSORS**

M. ROBERTS (Pilkington P.E., Ltd., St. Asaph, Wales) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 15.1-15.8. refs

The 8-13 micron thermal IR band offers the advantages of both day and night use; attention is presently given to an IR zoom lens system applicable to RPV sensor payloads in virtue of its compactness. The optical system comprises an IR scanner and afocal telescope optics, by which collimated thermal radiation from the scene is collected by the objective and focused at an intermediate point, from which it is in turn recollimated into the scanner pupil. Switchable optics, optically and mechanically compensated zoom optics, mechanical design, and testing considerations are discussed. O.C.

**A86-37342**

**THE PHOENIX SENSOR TURRET SYSTEM**

A. J. MCQUIGGAN (GEC Avionics, Ltd., Electro Optical Surveillance Div., Basildon, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 16.1-16.8.

The Phoenix sensor turret system's design features and operational capabilities are discussed. The Phoenix turreted, stabilized thermal imaging sensor comprises an imager, cryogenic cooling, and processing and stabilization electronics, integrated into a single LRU. This modular design has yielded a survivable and easily maintainable system whose versatility extends to the incorporation of alternative sensors; it is also applicable to RPVs other than Phoenix. Attention is given to the sensor telescope and cryogenic cooling system. O.C.

**A86-37343**

**APPLICATIONS OF SENSOR PAYLOADS**

J. W. JACK (Ferranti Defence Systems, Ltd., Electro-Optics Dept., Edinburgh, Scotland) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 17.1-17.7.

An account is given of the availability and performance capabilities of TV, intensified TV, pyroelectric vidicon, and thermal imaging systems applicable to visible to far-IR sensing tasks aboard RPV platforms. Attention is given to a number of payload configurations which, while conceived to meet a military requirement for the detection and recognition of a military vehicle, are not restricted to military applications. Civilian applications include thermal emission surveys for local governments and industrial concerns, traffic flow pattern surveillance, and pipeline and transmission line surveys. O.C.

**A86-38322**

**INSTALLATION OF A BLEED AIR HEATED RADOME/AIR MOTION SENSING SYSTEM ON A BEECH KING AIR 200 AIRCRAFT**

M. N. ZRUBEK (National Center for Atmospheric Research, Boulder, CO) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p.
(SAE PAPER 851811)

The Research Aviation Facility (RAF) of the National Center for Atmospheric Research (NCAR) has developed a nose mounted differential pressure air motion sensing system for a Beech King Air 200 aircraft that allows air motion sensing (small scale turbulence) in three axes (horizontal, vertical, and longitudinal) to be taken under a variety of atmospheric conditions. This system is incorporated into a custom designed radome which utilizes engine bleed air heat for anti-ice capability and allows the use of the aircraft storm avoidance radar. Author

**A86-38324*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**RETROFITTING AVIONICS - CLOSING THE PERFORMANCE 'GENERATION GAP'**

C. R. SPITZER (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p. refs
(SAE PAPER 851813)

The retrofitting of advanced avionics to in-service aircraft in order to increase operational safety and flexibility, and reduce operating costs is analyzed. Research in flight management planning and airborne guidance for full-and cost-effective flight is examined. The use of CRTs and thin film electroluminescent displays in aircraft is described. The development of more accurate and reliable fuel gauges using nuclear-based techniques or volumetric measurements to evaluate fluid levels is studied. Advances in airspace systems, such as the Microwave Landing System, and Air Traffic Control Beacon System/Select Mode, the Traffic Advisory and Collision Advance System, and satellite-based communications, navigation, and surveillance are discussed. I.F.

**A86-38345**

**THE INTEGRATED DIGITAL AVIONICS SYSTEM FOR THE F-20 TIGERSHARK**

W. L. SMITH (Northrop Corp., Aircraft Div., Hawthorne, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 16 p.
(SAE PAPER 851850)

Salient features of the avionics system to be discussed include: (1) a federated arrangement of the multiple processors in the system that maximizes mission reliability, (2) integration of the system using a MIL-STD-1553 multiplex data bus that minimizes the effects of changes and growth, and (3) a pilot-friendly cockpit using one head-up and two head-down displays and controls that allow combat with hands on stick and throttle. Author

**A86-38346**

**AVIONICS SYSTEM ARCHITECTURE FOR BEECHCRAFT STARSHIP 1**

C. A. FENWICK and J. L. SPENCER (Rockwell International Corp., Avionics Group, Cedar Rapids, IA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 19 p.
(SAE PAPER 851851)

The architectural design of avionics to be used in the Beechcraft Starship 1 aircraft is presented. The avionics system consists of an integrated array of over 70 electronic line replaceable units organized to provide unprecedented levels of functional capability, fault tolerance, and reconfigurability. The digital data communication network connects all avionics and many nonavionics systems, including engine and fuel sensors, through the use of a dual-dual set of data concentrators. As compared with the current avionics equipment, the advanced avionics concept will result in weight and volume reductions, fewer wires and an integrated data network, simplified cockpit operation, and enhanced reliability. I.S.

**N86-26321#** Thomson-CSF, Issy les Moulineaux (France).

**SYNTHETIC REAL-TIME RELIEF DISPLAY ALL-WEATHER AIRBORNE MISSIONS**

J. N. BOTELLA *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 4 p Oct. 1985
Avail: NTIS HC A07/MF A01

Within the context of all-weather airborne missions, it is necessary to provide the pilot with information on the external world, even, and particularly when information provided by radar or optronic sensors are failing. The development of altimetric digital data banks prompts investigations to examine the display of synthetic relief in a cockpit. The study of various mass storages shows that a color film has remarkable storage capacities. Altimetric data are stored on a film read by the MERCATOR reader (whose initial function is to read map images). Three-dimensional synthesis algorithms are used and they are provided with the exceptional possibilities enabled by the MERCATOR analysis. The philosophy of this study is to show how a unique product, the map reader MERCATOR, designed to display plane images, is used to perform tridimensional displays of relief. Author

**N86-26322#** Farrand Optical Co., Inc., Valhalla, N.Y.

**THE WIDE FIELD HELMET MOUNTED DISPLAY**

J. LARUSSA *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 7 p Oct. 1985 refs
Avail: NTIS HC A07/MF A01

The wide field helmet mounted display developed by the Farrand Optical Company, Inc. is described. This display provides the pilot with an instantaneous field of view of 60 deg vertically and 135 deg horizontally. The central field of view consists of an overlap field of 25 deg within which full stereopsis is available. It would appear that a new design which the Farrand Optical Company, Inc. is now in the process of designing for Aerospace Medical Research Laboratory (AMRK) would be applicable for night all weather operations where such data as flight path control, computed weapon projectories, synthetic outside world views, expected and unexpected threats and automatic terrain following paths would be displayed. The parameters that must be considered in designing a wide field helmet mounted display are discussed. Briefly, these parameters are size, weight and balance on the head, brightness of the display and see-through ability of the display. The discussion assumes the use of a one inch, high brightness, high resolution CRT input already developed and operational. Author

**N86-26323#** Marconi Avionics Ltd., Rochester (England). Aircraft and Missile Systems.

**A SOLID-STATE MAP DISPLAY FOR RAPID RESPONSE OPERATION**

D. J. POWELL and T. E. CRAYFORD *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 13 p Oct. 1985
Avail: NTIS HC A07/MF A01

A means to provide pilots with a presentation of a moving color map display on a standard color CRT is described. It uses solid-state techniques and derives the display from a digital database. The design criteria used in the development of the system are discussed and an overview of the system operation is presented. Finally, one of the many ways in which the system as a whole may be used in operation is addressed. Author

**N86-26335#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**METHOD FOR DETERMINING THE TIME DELAY OF THE PITOT-STATIC TUBING SYSTEM OF AIRCRAFT**

J. H. BREEMAN 17 Jun. 1985 19 p
(NLR-TR-83075-U; ESA-86-96978) Avail: NTIS HC A02/MF A01

The measurement of the response of the pitot-static tubing system of aircraft is described. A small jet transport is used as an example. Results of measurements performed on the ground and at an altitude of 3000 ft are reported. ESA

**N86-27280*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AIRCRAFT LIFTMETER Patent**
E. W. MILLEN, inventor (to NASA) 29 Apr. 1986 10 p Filed 8 Feb. 1984 Supersedes N84-32383 (22 - 22, p 3535) Sponsored by NASA. Langley Research Center
(NASA-CASE-LAR-12518-1; US-PATENT-4,586,140; US-PATENT-APPL-SN-578386; US-PATENT-CLASS-364-433; US-PATENT-CLASS-364-435; US-PATENT-CLASS-244-181; US-PATENT-CLASS-73-178T; US-PATENT-CLASS-340-968)
Avail: US Patent and Trademark Office CSCL 01D

A display for aiding the pilot of an aircraft in anomalous wind environments is described. Wind velocity components are measured by an instrument, processed by a computer and a vector generator, and then displayed as a vector. The display utilizes the measurements of ground speed and of wind velocity in three mutually perpendicular directions. This display will also show changes in lift of an aircraft. B.W.

## 07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-37331**
**P T A - DESIGN CONSIDERATIONS FOR AN AIRFRAME SYSTEM AND DETAILED DESIGN OF FUEL SUBSYSTEM**
P. SINGH, R. VENKATESH, and A. R. ACHYUTHA RAO (Aeronautical Development Establishment, Bangalore, India) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 12.1-12.15. refs

Pilotless Target Aircraft (PTAs) are turbojet-propelled, high subsonic cruise RPVs that can be used in several consecutive sorties for weapons development and fighter pilot training. Attention is presently given to the design features and performance characteristics of a PTA's fuel subsystems, which employ engine bleed air for pressurization. A detailed anticipation has been made of center-of-gravity shifts under various operational conditions, as well as of fuel system compressor bleed capacities for pressurization over the range of PTA engine rpm values. O.C.

**A86-37344**
**'A FLYWHEEL POWERED RPV LAUNCHER - PUTTING THEORY INTO PRACTICE'**
D. GRIFFIN (Frazer-Nash, Ltd., Kensington-upon-Thames, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 23.1-23.9. Research supported by the Ministry of Defence (Procurement Executive).

The present RPV launching system employs an electric motor-accelerated flywheel to store energy, which is then extracted in the form of nearly steady torque by electromagnetic slipping clutches. This torque is applied via high speed capstan and steel cable to a sliding beam which, in turn, carries a trolley with RPV attachment points. The launcher is transported aboard a Land Rover and operates in all weather conditions without smoke or vapor signatures; launch velocity and peak acceleration are adjustable for a range of RPV weights. O.C.

**A86-37345**
**A SPRING IN THE AIR**
T. C. NOTTINGHAM (Admiralty Research Establishment, Portsdown, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Supplementary Papers . Bristol, England, University of Bristol, 1985, p. 24.1-24.7.

Design considerations and a development history are presented for an inexpensive, low technology, spring-based RPV launch system. The choice of a spring was based on the linearity of its response, as well as its excellent fatigue life and imperviousness to atmospheric and temperature conditions. The launcher configuration uses the spring in compression in order to minimize hazards to operators in the event of linkage failure. O.C.

**A86-37827*#** Nielsen Engineering and Research, Inc., Mountain View, Calif.
**UNSTEADY FORCES ON COUNTER-ROTATING PROPELLER BLADES**
D. J. LESIEUTRE (Nielsen Engineering and Research, Inc., Mountain View, CA) and J. P. SULLIVAN (Purdue University, West Lafayette, IN) IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 229-236. refs
(Contract NSG-3135)
(AIAA PAPER 86-1804)

Unsteady forces experienced by counter-rotating propeller blades are examined in this paper. A fully coupled vortex lattice model of counter-rotation is used to obtain a quasi-steady solution to the propeller loadings, and an unsteady Sears (1941) analysis provides an estimate of the unsteady loads from the quasi-steady results. The vortex lattice method predicts the overall performance of counter-rotation well, based on comparisons of measured and predicted results. The effects of propeller spacing and blade number on the unsteady loadings are investigated. The peak-to-peak variation about the mean of the unsteady loads on the rear propeller varied from 9 percent for a 2 x 2 counter-rotation system to 2 percent for an 8 x 8 system. Author

**A86-38334**
**RELIABILITY AND MAINTAINABILITY - A LOOK AT THE ROLLS-ROYCE RB.211**
R. G. JACKSON (Rolls-Royce, Inc., Greenwich, CT) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p.
(SAE PAPER 851829)

This paper addresses the Reliability and Maintainability aspects of the Rolls-Royce RB.211 high by-pass engine, which entered airline service more than 13 years ago. Improvements in Reliability, a new approach to engine management, both in-shop and on-wing, and the importance of Maintainability features are discussed. Reference is also included to performance retention over extended calendar periods, and the eventual achievement of extremely high rates of Reliability, as the various lessons learned over the years are applied to derivative engine models. Author

**A86-38892*#** Purdue Univ., West Lafayette, Ind.
**PASSIVE CONTROL OF AERODYNAMICALLY FORCED VIBRATIONS OF SUPERSONIC TURBOMACHINE ROTORS BY SPLITTER BLADES**
S. FLEETER, D. A. TOPP (Purdue University, West Lafayette, IN), and D. HOYNIAK (NASA, Lewis Research Center, Cleveland, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 77-88. NASA-supported research. refs
(AIAA PAPER 86-0844)

An aeroelastic model is developed to examine the use of splitter blades as a passive detuning mechanism for flow induced forced response of unstalled supersonic turbomachine rotors. The splitters introduce aerodynamic and structural detuning to the rotor design. The relationship between aerodynamic and structural detuning and the location and chord lengths of splitters is analyzed. The model is applied to the flow induced response of four 12-blade rotors with Verdon's (1973) Cascade B flow geometry. The data reveal that for gusts characterized by forward and backward traveling waves the splitters generally decrease the maximum amplitudes of response; however, for some gust load interblade phase angles, such as -180 deg and 120 deg the splitters did not reduce the amplitudes of response. I.F.

**A86-38894*#** Purdue Univ., West Lafayette, Ind.

**THREE DIMENSIONAL UNSTEADY AERODYNAMICS AND AEROELASTIC RESPONSE OF ADVANCED TURBOPROPS**

M. H. WILLIAMS and C.-C. HWANG (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 116-124. refs
(Contract NAG3-499)
(AIAA PAPER 86-0846)

A method for the prediction of steady and unsteady aerodynamic loads and aeroelastic response of advanced turboprops is presented. The aerodynamic analysis uses three dimensional unsteady linearized compressible flow theory to compute the blade pressure distribution. The aeroelastic analysis is based on a normal mode representation of the structure. The method is applicable to both conventional and advanced turbo-prop configurations, provided that blade stall and transonic shock waves are not important factors. Aerodynamic results are presented which validate the model in various limits by comparisons to alternative theories and experimental data. Finally, results of a stability analysis of an advanced turboprop are given, with comparisons to measurements made at NASA Lewis Research Center. Author

**A86-38927#**

**DURABILITY PREDICTION OF PARALLEL FUEL TANK SKINS WITH FLUID-STRUCTURE INTERACTION DYNAMICS**

M. A. FERMAN, M. D. HEALEY, W. H. UNGER (McDonnell Aircraft Co., Saint Louis, MO), and M. D. RICHARDSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 456-463. refs
(AIAA PAPER 86-0935)

Premature fatigue of parallel fuel tank skins due to fluid-structure interaction loading is addressed and is believed to explain some of the widespread leakage of military aircraft. Earlier effort with a single flat panel was extended to parallel panels configured as sides or top/bottom combinations. This expansion of the concept brings it one step closer to a general method where the in-flight and general vibration environments producing this effect can be included along with the manouver spectrum loading in design and application. A combined analytical and experimental approach was used. Author

**A86-38949#**

**AEROELASTIC TAILORING OF ADVANCED COMPOSITE COMPRESSOR BLADES**

O. O. BENDIKSEN and J. F. WHITE, III (Princeton University, NJ) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 684-692. refs
(AIAA PAPER 86-1008)

An analytical investigation of aeroelastic tailoring concepts for compressor blades is presented. The study is based on a Rayleigh-Ritz formulation with five elastic degrees-of-freedom per blade, including a plate-type mode to account for chordwise bending. A linearized two-dimensional supersonic cascade theory is used to calculate the unsteady aerodynamic forces. The chordwise mode is highly unstable for low aspect ratio composite blades with little or no sweep of the laminate fibers. A moderate aft fiber sweep produces bending-torsion coupling which is stabilizing on the first torsion branch, but which is destabilizing on the first bending branch. Forward fiber sweep is generally destabilizing except on the chordwise branch. By using a crossed-ply laminate configuration, a highly unstable blade section is successfully stabilized up to a Mach number of 1.55. The corresponding titanium blade is unstable for all supersonic Mach numbers. Author

**A86-38956**

**OFF-DESIGN OPERATION OF TURBOMACHINES [FONCTIONNEMENT HORS ADAPTATION DES TURBOMACHINES]**

V. BENSIMHON (SNECMA; Ecole Nationale Superieure de l'Aeronautique, Paris; Ecole Speciale des Travaux Aeronautiques, Orsay, France) Paris, Masson, 1986, 175 p. In French.

The importance of geometry in the calculation of engine off-design operation and on the various independent parameters determining engine performance is considered in addition to the impact of flight condition or geometry change on performance. A study of engine components is followed by an examination of the advantages and disadvantages of various turbomachines, both in terms of performance and aircraft integration. Aerodynamic, thermal, and mechanical engine component limits are considered in the physical construction of turbomachines such as the single-spool turbojet, double-spool turbojet, double-spool turbofan, and the turbofan. R.R.

**A86-38994#**

**A MATHEMATICAL MODEL FOR CALCULATION OF EFFECTS OF AIR HUMIDITY FUEL COMPOSITION AND GAS DISSOCIATION ON ENGINE PERFORMANCE AND ITS ACTUAL APPLICATION**

Y. GU (Nanhua Powerplant Research Institute, Zhuzhou, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Feb. 1986, p. 51-55. In Chinese, with abstract in English.

**A86-38998#**

**TEMPERATURE DISTRIBUTION INVESTIGATION AT THE OUTLET OF AN ANNULAR COMBUSTOR OF P TYPE TURBOJET ENGINE**

B. ZHANG (Shenyang Aeronautics Institute, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Feb. 1986, p. 78-80. In Chinese, with abstract in English.

Some problems of temperature distribution at the outlet of an annular combustor of a P type turbojet engine are described. The change law of maximum temperature, thermal zones, and the stability in the temperature field are demonstrated. The appropriate radial temperature distribution can be obtained by adjusting the mass flow ratio through the inner and outer annular ducts within the range of 0.94-0.96. The effects of supports, tubes, and ignitors on the temperature distribution of the annular combustor are less than that of a can-ring. Author

**A86-39079#**

**IDENTIFICATION OF LONGITUDINAL ACOUSTIC MODES ASSOCIATED WITH PRESSURE OSCILLATIONS IN RAMJETS**

W. H. CLARK (U.S. Navy, Naval Weapons Center, China Lake, CA) and J. W. HUMPHREY Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, May-June 1986, p. 199-205. Previously cited in issue 16, p. 2286, Accession no. A84-35665. refs

**A86-39086#**

**SURFACE LAYER ACTIVATION TECHNIQUE FOR MONITORING AND IN SITU WEAR MEARUREMENT OF TURBINE COMPONENTS**

C. C. BLATCHLEY and P. SIOSHANSI (Spire Corp., Bedford, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, May-June 1986, p. 248-252. Previously cited in issue 17, p. 2434, Accession no. A84-37652. refs

**A86-39568#**

**SURGE MARGIN ENHANCEMENT BY A POROUS THROAT DIFFUSER**

J. A. RAW (Pratt and Whitney Canada, Inc., Longueil) (CASI, Annual General Meeting, 32nd, Montreal, Canada, May 27, 28, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 54-60.

An aerodynamic fix has been devised for the diffuser of a centrifugal compressor to increase the stalling range of the diffuser significantly. The advent of lightweight composite helicopter rotors has reduced the inertia of rotor blades, creating a situation where the rotors can rapidly lose speed. The helicopter engines must therefore be able to accelerate quickly to prevent 'droop' from occurring. The acceleration must be from zero to maximum power in 2 sec, twice as fast as the previous top performance. Previous tests had shown that the surge margin in a compressor diffuser (CD) could be expanded by making the CD walls porous, thereby linking the diffuser throats by a communication manifold, equalizing pressures in the throats and making all diffuser blades reach stall at the same time instead of some before others. The gain in surge margin is sufficient to meet the new acceleration demands at a cost of only one percent of efficiency. The concept is in trials in the PT6 B-36 engine on a Sikorsky S-76 helicopter. Early test results have confirmed the enhanced transient engine response at a negligible efficiency loss. M.S.K.

**A86-39725#**

**GAS AND EROSION CORROSION OF THE COMBUSTION CHAMBERS OF AIRCRAFT ENGINES [GAZOWA I EROZYJNA KOROZJA KOMOR SPALANIA SILNIKOW LOTNICZYCH]**

L. DROZDZ and R. GRUCHALSKI (WSK PZL, Rzeszow, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 40, Nov.-Dec. 1985, p. 6, 7. In Polish.

The mechanisms of the gas and erosion corrosion of the turbine blades and combustion chambers of aircraft engines are examined. In particular, attention is given to the effect of vanadium, molybdenum, and sulfur contents in the combustion products on the corrosion of turbine blades of Cr-Ni steels of various compositions; the effect of sulfur on gas corrosion of Cr-Ni steels is shown to be particularly strong. Experimental data on the erosion corrosion of a combustion chamber of EI435 alloy are reported, and photographs of areas damaged by erosion corrosion are presented. V.L.

**N86-26338#** Aeronautical Research Labs., Melbourne (Australia).

**THE GENERAL ELECTRIC F404 - ENGINE OF THE RAAF'S NEW FIGHTER**

D. FRITH Jul. 1985 55 p refs

(AD-A164562; ARL-AERO-PROP-TM-426) Avail: NTIS HC A04/MF A01 CSCL 21E

The F404 engine in the F/A-18 is representative of a new generation of military turbofan engines. The features of the engine that govern its performance and contribute to its maintainability are discussed. The intention is to give the non-specialist an appreciation of those factors materially affecting the operation of this type of engine. The RAAF F/A-18 Hornets are powered by two General Electric F404-GE-400 augmented turbofan engines. The 3-stage fan, driven by the low-pressure turbine, compresses inlet air that subsequently divides into the bypass and core flows. Variable inlet guide vanes schedule the direction of the flow into the fan as a function of rotational speed. The core flow is further compressed for entry to the annular combustor by the compressor, driven by the high-pressure turbine. Variable inlet guide and two rows of stators adjust the flow direction as a function of corrected compressor speed. After expansion through the turbines, the high temperature gas from the combustion process is mixed with the bypass air to form the high speed jet out of the exhaust nozzle. When operating in afterburning mode, the speed of this jet is increased by additional combustion in the afterburner. GRA

**N86-27282*#** Hamilton Standard, Windsor Locks, Conn.

**LARGE-SCALE ADVANCED PROP-FAN (LAP) PITCH CHANGE ACTUATOR AND CONTROL DESIGN REPORT**

R. A. SCHWARTZ, P. CARVALHO, and M. J. CUTLER 31 Jan. 1986 187 p Original document contains color illustrations

(Contract NAS3-23051)

(NASA-CR-174788; NAS 1.26:174788) Avail: NTIS HC A09/MF A01 CSCL 01A

In recent years, considerable attention has been directed toward improving aircraft fuel consumption. Studies have shown that the high inherent efficiency previously demonstrated by low speed turboprop propulsion systems may now be extended to today's higher speed aircraft if advanced high-speed propeller blades having thin airfoils and aerodynamic sweep are utilized. Hamilton Standard has designed a 9-foot diameter single-rotation Large-Scale Advanced Prop-Fan (LAP) which will be tested on a static test stand, in a high speed wind tunnel and on a research aircraft. The major objective of this testing is to establish the structural integrity of large-scale Prop-Fans of advanced construction in addition to the evaluation of aerodynamic performance and aeroacoustic design. This report describes the operation, design features and actual hardware of the (LAP) Prop-Fan pitch control system. The pitch control system which controls blade angle and propeller speed consists of two separate assemblies. The first is the control unit which provides the hydraulic supply, speed governing and feather function for the system. The second unit is the hydro-mechanical pitch change actuator which directly changes blade angle (pitch) as scheduled by the control. Author

**N86-27283*#** Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.

**STRUCTURAL TAILORING OF ENGINE BLADES (STAEBL) THEORETICAL MANUAL**

K. W. BROWN Mar. 1985 51 p

(Contract NAS3-22525)

(NASA-CR-175112; NAS 1.26:175112; PWA-5774-40) Avail: NTIS HC A04/MF A01 CSCL 21E

This Theoretical Manual includes the theories included in the Structural Tailoring of Engine Blades (STAEBL) computer program which was developed to perform engine fan and compressor blade numerical optimizations. These blade optimizations seek a minimum weight or cost design that satisfies practical blade design constraints, by controlling one to twenty design variables. The STAEBL constraint analyses include blade stresses, vibratory response, flutter, and foreign object damage. Blade design variables include airfoil thickness at several locations, blade chord, and construction variables: hole size for hollow blades, and composite material layup for composite blades. Author

**N86-27284*#** Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.

**STRUCTURAL TAILORING OF ENGINE BLADES (STAEBL) USER'S MANUAL**

K. W. BROWN Mar. 1985 106 p

(Contract NAS3-22525)

(NASA-CR-175113; NAS 1.26:175113; PWA-5774-39) Avail: NTIS HC A06/MF A01 CSCL 21E

This User's Manual contains instructions and demonstration case to prepare input data, run, and modify the Structural Tailoring of Engine Blades (STAEBL) computer code. STAEBL was developed to perform engine fan and compressor blade numerical optimizations. This blade optimization seeks a minimum weight or cost design that satisfies realistic blade design constraints, by tuning one to twenty design variables. The STAEBL constraint analyses include blade stresses, vibratory response, flutter, and foreign object damage. Blade design variables include airfoil thickness at several locations, blade chord, and construction variables: hole size for hollow blades, and composite material layup for composite blades. Author

# 08

# AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-37332**
**DESIGNING COMPACT ELECTROMECHANICAL ACTUATORS FOR FLIGHT CONTROL**
J. MABIE (Kollmorgen Corp., Inland Motor Div., Radford, VA) and G. HORNER (Hightech Components, Ltd., Tadley, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 13.1-13.6.

The electromechanical actuator described in this paper was designed to be used for primary flight control of a subsonic target drone. The actuator includes a motor, failsafe brake, gearing, dual feedback potentiometer and electronics all contained within a totally sealed housing. The electronics consist of a position servo amplifier with a Pulse Width Modulated power stage as well as filtering to meet stringent Electromagnetic Interference requirements. This paper describes the design process including design choices, analysis and experimental effort expended to ensure that the actuator would go through the battery of qualification tests with minimal complications. Author

**A86-37335**
**A REAL-TIME SIMULATION OF A NON-LINEAR RPV INCORPORATING HEAD-UP TYPE COLOUR GRAPHICS**
P. P. ASLIN, J. V. HATFIELD, R. J. PATTON (York, University, Heslington, England), and A. J. A. OXTOBY (Hull, University, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 21.1-21.13. SERC-supported research. refs

The 'Machan' RPV was designed to serve as an R&D vehicle for the development of flight control laws as well as for surveillance duties. Using comparatively modest computing power, a simulation of the Machan RPV has been developed which allows the assessment of aircraft performance on-line in both open loop and closed loop configurations. The simple control structure obtained furnishes a baseline stability augmentation system, and is used as an inner loop design. O.C.

**A86-37407#**
**DESIGN FEATURES OF AUTOMATIC CONTROL SYSTEM OF D-4 RPV**
W. XIE and B. LIU Northwestern Polytechnical University, Journal, vol. 4, April 1986, p. 217-226. In Chinese, with abstract in English. refs

Design features incorporated into the Chinese D-4 remotely piloted vehicle (RPV) to achieve stable flight and a vertical orientation for the on-board instrumentation are described, along with the results of several aerial surveys with different instruments. Trackkeeping performance of the RPV has reached a 25 m accuracy by equipping the aircraft with a laser range finder and an autopilot. The pitch and bank angles of the platform have been stabilized to 2 deg within the vertical using low-cost components. Installation of an on-board cesium light pump magnetic probe has permitted aeromagnetic prospecting at a scale of 1:10,000. Aerophotogrammetry has been performed at a scale of 1:20,000 for examining soil erosion around the Yellow River. M.S.K.

**A86-37828#**
**A METHOD FOR ESTIMATING JET REACTION CONTROL EFFECTIVENESS**
R. E. KUHN IN: Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 237-242. Research supported by Rockwell International Corp. refs
(AIAA PAPER 86-1805)

The interaction of the free stream with the jet flow from reaction jets used for control of V/STOL and STO-VL aircraft in hover and transition can reduce the effectiveness of these controls. The limited data available on effects of jet location on the effectiveness of jet reaction control are examined and a method for estimating the loss in effectiveness is presented. The empirical method is based on the data from only two investigations. Additional studies are needed to verify the range of applicability. Author

**A86-38323**
**WIND SHEAR STUDIES AND COCKPIT INTEGRATION**
C. R. HIGGINS (Boeing Commercial Airplane Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 13 p.
(SAE PAPER 851812)

Starting with a brief review of the history of wind shear-related accidents and incidents over the last 20 years, the pilot view of the wind shear encounter from the cockpit will be presented. With this view as the basis, the human-factors aspect of the wind shear encounter will be discussed. Based on this insight, cockpit systems developed to aid the crew in an inadvertent wind shear encounter will be reviewed. Author

**A86-38329*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**PIVOTABLE STRAKES FOR HIGH ANGLE OF ATTACK CONTROL**
P. J. BOBBITT and J. T. FOUGHNER, JR. (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 13 p. refs
(SAE PAPER 851821)

A series of pivotable strakes have been tested in combination with a 44-deg swept wing to determine their ability to provide pitch control at high angles of attack. The tests were carried out in the Langley 7 X 10-Foot High-Speed tunnel at nominal Mach numbers of 0.3 to 0.4. A total of five strakes with various aspects ratios and shapes were tested at negative deflection angles of 5, 10, 15, and 20 deg through an angle of attack range up to approximately 50 deg. In addition, a cranked delta wing with 70-deg sweep was tested with two different pivotable apex flaps. This paper shows lift, drag and moment data for the complete configurations as well as for the separate contributions of the strakes and fuselage nose which are mounted on a second balance. Generally, strake deflection was found to have a significant effect on moment while lift/drag changed very little. Author

**A86-38331**
**APPLICATION OF ANALYTICAL REDUNDANCY**
R. C. HENDRICK (Honeywell, Inc., Minneapolis, MN) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p.
(SAE PAPER 851825)

Analytical redundancy involves the use of diagnostic routines in software to detect a fault in a set of sensor signals. The fault detection algorithms and associated redundancy management structure are presented within. The DIGITAC application improved the mission reliability of existing dual mission-essential sensors by effecting a single-fail-operative capability. Flight safety was preserved for single sensors. Fault detection qualities of the diagnostics were satisfactory. False alarm problems required considerable redesign and tuning to properly model the processes. These problems were satisfactorily solved with the exception of diagnostic errors occurring during extreme turbulence (e.g., penetration of jetwash). Author

**A86-38332**

### DIGITAC MULTIMODE CONTROL LAWS

R. C. HENDRICK (Honeywell, Inc., Minneapolis, MN) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p.
(SAE PAPER 851826)

The DIGITAC system executes multiple control laws, each tailored to specific mission tasks. The available augmentation modes include the standard control augmentation mode for the A-7D aircraft, a 'flight path' mode, and a 'precision attitude' mode. Synthesis and development of the control laws for these modes are described within this paper. Also described are unique filtering, amplitude sensitive performance, and robust directional control. It was demonstrated that the standard flight modes were executed by the digital system in an un-degraded manner. Major performance improvements were produced for gunnery tasks by the precision attitude mode. Author

**A86-38333**

### USAF TEST PILOT SCHOOL USE OF DIGITAC IN SYSTEMS TESTING

D. R. FURMAN (USAF, Test Pilot School, Edwards AFB, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p.
(SAE PAPER 851827)

The U.S. Air Force Test Pilot School has employed the YA-7D DIGITAC in its curriculum since 1976. To date a dozen projects have been carried out by student classes using the DIGITAC, investigating improved directional control, the effect of depressed roll axis on air-to-air tracking, and airborne verification of computer-simulated flying qualities. Future tests will help to provide answers to questions arising during the design and testing of new highly augmented flight control systems. Author

**A86-38930#**

### A WIND TUNNEL STUDY OF ACTIVE CONTROL TECHNOLOGY ON A HIGH ASPECT RATIO WING

H. HORIKAWA and K. SAITO (Kawasaki Heavy Industries, Ltd., Aircraft Engineering Div., Kakamigahara, Japan) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 484-492. Research supported by the Society of Japanese Aerospace Companies. refs
(AIAA PAPER 86-0956)

Gust load alleviation (GLA) and flutter mode control (FMC) of a transport wing have been studied in a low speed wind tunnel. A 1/9 scale semispan wing model, which represents a 150-passenger transport, is mounted in the wind tunnel and controlled by a trailing-edge control surface activated electrically. A gust for the gust load alleviation test is generated through the use of both a fluttering banner and a grid. Digital control utilizing a microcomputer is employed for implementing the flutter mode control. The objectives of this study are the development of a low-budget wind tunnel model with active controls as well as a demonstration of the effectiveness of gust load allevation and flutter mode control on the transport wing. A modified linear quadratic Gaussian (LQG) synthesis procedure has been used to design low-order robust controllers for the flutter mode control. In general, analytical results are in good agreement with experimental ones. Author

**A86-38932#**

### DYNAMIC INTERACTIONS BETWEEN ACTIVE CONTROL SYSTEMS AND A FLEXIBLE AIRCRAFT STRUCTURE

R. FREYMANN (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 517-524. refs
(AIAA PAPER 86-0960)

Analytical and experimental results from three different research programs in the field of active control are presented. Attention is focussed on special problems related to interaction effects between active control systems and aircraft structures. Furthermore, various viewpoints for the design of active control systems are illustrated and the extent to which adaptive control systems can contribute to an improvement of the stability margins of such systems is shown. Author

**A86-38946*#** PRC Kentron, Inc., Hampton, Va.

### INTEGRATED AEROSERVOELASTIC TAILORING OF LIFTING SURFACES

T. A. ZEILER (PRC-Kentron, Inc., Hampton, VA) and T. A. WEISSHAAR (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 654-663. refs
(Contract NAG1-157)
(AIAA PAPER 86-1005)

An approach to the integration of two design activities, structural design and active control design, for a highly idealized aeroservoelastic system is presented. The particular design goal for this study is the maximization of the stable airspeed envelope of an idealized model of an aeroservoelastic system through rational and systematic variation of structural and control design parameters. The steady-state linear quadratic regulator is used to model the control subsystem; the structural subsystem is assigned characteristic design parameters, such as shear center position. The application of the procedure described here produces optimally controlled structures with stability characteristics superior to those of open-loop and initial closed-loop designs. V.L.

**A86-39041#**

### DESIGN OF A FLUTTER MODE CONTROLLER USING POSITIVE REAL FEEDBACK

G. L. SLATER (Cincinnati, University, OH) and M. TAKAHASHI (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 246-253) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 339-345. Previously cited in issue 21, p. 2999, Accession no. A84-43427. refs
(Contract F33615-82-K-3609)

**A86-39042*#** Purdue Univ., West Lafayette, Ind.

### FREQUENCY DOMAIN SYNTHESIS OF A ROBUST FLUTTER SUPPRESSION CONTROL LAW

D. K. SCHMIDT (Purdue University, West Lafayette, IN) and T. K. CHEN (Lear Siegler, Inc., Dayton, OH) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 459-467) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 346-351. Previously cited in issue 13, p. 1850, Accession no. A85-30373. refs
(Contract NAG1-157)

**A86-39043#**

### CLASSICAL FLIGHT DYNAMICS OF A VARIABLE FORWARD-SWEEP-WING AIRCRAFT

R. L. SWAIM (Oklahoma State University, Stillwater) and B. A. NEWMAN Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 352-356. refs

The X-29 advanced technology demonstrator has established the design of forward-sweep wings. A conceivable variation of forward sweep is variable forward sweep. A variable forward-sweep configuration would likely offer higher performance levels than either forward sweep or variable sweep. The classical flight dynamics for such a configuration are determined and discussed. A classical aircraft stability analysis assuming rigid body, linearized dynamics, and no stability augmentation is used. Results indicated variable forward-sweep configurations can have less of a problem with excessive static margins than variable backward-sweep configurations. Wing location and center of gravity location changes due to variable forward sweep affect the stability derivatives consistently more than the wing shape changes due to variable forward sweep. The steady state trim condition and moments of inertia changes due to variable forward sweep and Mach number are small. The phugoid and roll modes experience the largest effects due to variable forward sweep and Mach number. The average handling quality levels experience no drastic changes due to variable forward sweep and Mach number. Author

**A86-39768#**

**THE EQUIVALENT DETERMINISTIC FUNCTION OF THE DRYDEN'S SPECTRA OF ATMOSPHERIC TURBULENCE AND ITS APPLICATION TO THE AIRCRAFT RESPONSE PROBLEM**

Y. XIAO (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, April 1986, p. 198-204. In Chinese, with abstract in English.

The equivalent deterministic input technique (EDIT) for multiinput-random processes published recently by Etkin et al. (1984) is reviewed briefly in this paper. Then, a formula of linear transformation is derived and the singularity of the equivalent input function is shown. By analyzing the characteristics of the turbulence spectral matrix for the longitudinal motion of an aircraft, including two gust velocities and one gust gradient, it turns out that only two (rather than three) equivalent input vectors are needed. The Dryden spectra of atmospheric turbulence in current use are decomposed into U11, U22, U33, and the inversed Fourier transform is subsequently performed to obtain the equivalent deterministic function u11, u22, u32 for the reference flight condition. These curves are then fitted by simple expressions. The method and procedure for numerical computation or simulation of the aircraft response to turbulence in the time domain are proposed and discussed. A numerical example is given for comparing the results from the EDIT and the power spectral technique. Author

**N86-26339*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DECOUPLING CONTROL SYNTHESIS FOR AN OBLIQUE-WING AIRCRAFT**

G. S. ALAG (University of Western Michigan, Kalamazoo), R. W. KEMPEL, and J. W. PAHLE Jun. 1986 12 p refs Presented at the American Control Conference, Seattle, Wash., 18-20 Jun. 1986

(NASA-TM-86801; H-1339; NAS 1.15:86801) Avail: NTIS HC A02/MF A01 CSCL 01C

Interest in oblique-wing aircraft has surfaced periodically since the 1940's. This concept offers some substantial aerodynamic performance advantages but also has significant aerodynamic and inertial cross-coupling between the aircraft longitudinal and lateral-directional axes. This paper presents a technique for synthesizing a decoupling controller while providing the desired stability augmentation. The proposed synthesis procedure uses the concept of a real model-following control system. Feedforward gains are selected on the assumption that perfect model-following conditions are satisfied. The feedback gains are obtained by using eigensystem assignment, and the aircraft is stabilized by using partial state feedback. The effectiveness of the control laws developed in achieving the desired decoupling is illustrated by application to linearized equations of motion of an oblique-wing aircraft for a given flight condition. Author

**N86-26340*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AEROELASTIC CONTROL OF OBLIQUE-WING AIRCRAFT**

J. J. BURKEN, G. S. ALAG, and G. B. GILYARD (University of Western Michigan, Kalamazoo) Jun. 1986 12 p refs Presented at the American Control Conference, Seattle, Wash., 18-20 Jun. 1986

(NASA-TM-86808; H-1346; NAS 1.15:86808) Avail: NTIS HC A02/MF A01 CSCL 01B

The U.S. Navy and NASA are currently involved in the design and development of an unsymmetric-skew-wing aircraft capable of 65 deg wing sweep and flight at Mach 1.6. A generic skew-wing aircraft model was developed for 45 deg wing skew at a flight condition of Mach 0.70 and 3048 m altitude. At this flight condition the aircraft has a wing flutter mode. An active implementable control law was developed using the linear quadratic Gaussian design technique. A method of modal residualization was used to reduce the order of the controller used for flutter suppression. Author

**N86-26341*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**VALIDATION OF A NEW FLYING QUALITY CRITERION FOR THE LANDING TASK**

D. T. BERRY and S. K. SARRAFIAN 1986 10 p Presented at the AIAA Atmospheric Flight Mechanics Conference, Williamsburg, Va., 18-20 Aug. 1986

(NASA-TM-88261; H-1357; NAS 1.15:88261; AIAA-86-2126-CP) Avail: NTIS HC A02/MF A01 CSCL 01C

A strong correlation has been found to exist between flight path angle peak overshoot and pilot ratings for the landing task. The use of flightpath overshoot as a flying quality metric for landing is validated by correlation with four different in-flight simulation programs and a ground simulation study. Configurations tested were primarily medium-weight generic transports. As a result of good correlation with this extensive data base, criterion boundaries are proposed for landing based on the flight path peak overshoot metric. Author

**N86-26342*#** Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.

**STUDY ON USING A DIGITAL RIDE QUALITY AUGMENTATION SYSTEM TO TRIM AN ENGINE-OUT IN A CESSNA 402B**

K. E. DONALDSON 1986 37 p refs

(Contract NAG1-345)

(NASA-CR-177272; NAS 1.26:177272; KU-FRL-6132-3) Avail: NTIS HC A03/MF A01 CSCL 01C

A linear model of the Cessna 402B was used to determine if the control power available to a Ride Quality Augmentation System was adequate to trim an engine-out. Two simulations were completed: one using a steady state model, and the other using a state matrix model. The amount of rudder available was not sufficient in all cases to completely trim the airplane, but it was enough to give the pilot valuable reaction time. The system would be an added measure of safety for only a relatively small amount of development. Author

**N86-26343#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**FAILURES IN ADVANCED FLIGHT CONTROL SYSTEMS OF FUTURE TRANSPORT AIRCRAFT**

M. F. C. VANGOOL and W. W. RICKARD (McDonnell-Douglas Corp., Long Beach, Calif.) 12 Nov. 1984 187 p refs

(Contract NIVR-1745; RB-RLD-84/83-1.3.1)

(NLR-TR-84108-U; ESA-86-96983) Avail: NTIS HC A09/MF A01

Failure probability and the effects of flight control system failures on handling qualities of a medium-weight transport with reduced stability equipped with a side-stick controlled fly-by-wire flight control system were studied in a flight simulator. A very simple electrical back-up system was used to reduce the pitch divergence when the primary flight control system failed. Results indicate that a large variability in pilot ratings can occur in this kind of investigation. However, analysis of the ratings and the associated

commentary provides a ranking of the configurations used from good to bad. The results are compared to the existing criteria for handling qualities. It is shown that the rankings correlate well with closed-loop performance criterion, and Mil-F-8785 C criteria, whereas other criteria are either not applicable (time history criteria), or inappropriate (static stability criterion, bandwidth criterion).
ESA

**N86-27289#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
**A COMPUTER PROGRAMME FOR DATCOM METHODS OF ESTIMATION OF LATERAL STABILITY AND CONTROL DERIVATIVES**
S. RAMABHADRAN and H. SUNDARAMURTHY Mar. 1986 46 p
(NAL-TM-AE-8601) Avail: NTIS HC A03/MF A01

A computer code has been developed to estimate the lateral stability and control derivatives of aircraft configuration. The code, in general, is based on USAF DATCOM methods; in the case of a few derivatives, some approximate relations are used. The code estimates nine important lateral derivatives and five control derivatives. A brief review of the methods along with the limitations of DATCOM are presented. A comparison between the results of the code with those of the working examples of DATCOM are given for some cases. Application of the code for typical configurations is discussed. Author

**N86-27290*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT) FLIGHT-FLUTTER TEST PROGRAM**
M. W. KEHOE May 1984 20 p
(NASA-TM-84907; H-1183; NAS 1.15:84907) Avail: NTIS HC A02/MF A01 CSCL 01C

The highly maneuverable aircraft technology (HiMAT) vehicle was evaluated in a joint NASA and Air Force flight test program. The HiMAT vehicle is a remotely piloted research vehicle. Its design incorporates the use of advanced composite materials in the wings, and canards for aeroelastic tailoring. A flight-flutter test program was conducted to clear a sufficient flight envelope to allow for performance, stability and control, and loads testing. Testing was accomplished with and without flight control-surface dampers. Flutter clearance of the vehicle indicated satisfactory damping and damping trends for the structural modes of the HiMAT vehicle. The data presented include frequency and damping plotted as a function of Mach number. Author

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-37176**
**AEROSPACE SIMULATION II; PROCEEDINGS OF THE SECOND CONFERENCE, SAN DIEGO, CA, JANUARY 23-25, 1986**
M. UNG, ED. (Southern California, University, Los Angeles, CA) San Diego, CA, Society for Computer Simulation (Simulation Series. Volume 16, No. 2, 1986), 1986, 304 p. For individual items see A86-37177 to A86-37195.

Papers are presented on techniques for optimizing computer performance in real-time flight simulation; the effects of simulator variation on the fidelity of a UH-60 Black Hawk simulation; a real-time simulation for helicopter rotor wind-tunnel operations; simulation support software in a real-time environment; simulation of auto-rendezvous and docking; a generic missile weapon system model for war-gaming; and the optimal missile nonlinear multiloop controller design principle. Topics discussed include the modeling of a tethered two-body system in space; the testing of a spacecraft attitude control system; Space Station dynamic modeling; interactive mission planning for a Space Shuttle flight experiment; hybrid simulation of ejection seat dynamics, adaptive autoregressive target modes' identification; and optimal control of air-launched homing missiles using realistic performance indices. Consideration is given to flow separation and dynamic stall research, transonic trailing edge flow, fluid dynamics, man/machine interface, computer generated image time delays, the simulation of a satellite attitude control system, and the application of flight simulators to the development of advanced fighter flight control. I.F.

**A86-37178*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**EFFECTS OF SIMULATOR VARIATIONS ON THE FIDELITY OF A UH-60 BLACK HAWK SIMULATION**
W. B. CLEVELAND (NASA, Ames Research Center, Moffett Field, CA) and A. ATENCIO, JR. (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 13-26. refs

The validity of the vertical motion simulator used to simulate the UH-60A Black Hawk helicopter is evaluated. Aircraft simulation of bob-up, hover turn, and dash/quick stop manuevers are compared to actual flight data. The effects of variations in the simulator's visual and motion characteristics on the simulation data are investigated. Data obtained with the nonintrusive parameter identification procedure and optimal control measures are applied to the helicopter math model used for real-time aircraft simulation. Analysis of the model reveals that the simulated aircraft is underdamped, and the changes in the visual reference have the greatest effect on the ability of the pilot to perform the maneuvers. I.F.

**A86-37179*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**REAL-TIME SIMULATOR FOR HELICOPTER ROTOR WIND-TUNNEL OPERATIONS**
P. D. TALBOT, R. L. PETERSON, and D. R. GRAHAM (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 27-40.

This paper describes the elements and operation of a simulator that is being used to train operators of the Rotor Test Apparatus (RTA) in the large-scale 40- by 80-Foot Wind Tunnel at Ames Research Center. The simulator, named TUTOR (for Tunnel Utilization Trainer with Operating Rotor) duplicates the controls of the rotor and its dynamic behavior, as well as the wind-tunnel controls. The simulation software uses a preexisting blade-element model of a four-bladed rotor with flapping and lead-lag degrees of freedom. Equations were developed for all hardware and controls of the RTA and of the wind tunnel that are normally required to perform a wind-tunnel test of a helicopter rotor. The simulator hardware consists of consoles designed to have the same appearance and functions as those in the control room of the 40- by 80-Foot Wind Tunnel, allowing input from three operators who normally establish the required operating conditions during a test run. Normal operating procedures can be practiced, as well as simulated emergencies such as rotor power failure. Author

**A86-37337**
**A NEW COMPRESSED AIR LAUNCHING SYSTEM**
C. I. CAMPBELL (GQ Defence Equipment, Ltd., Goldaming, England) IN: Remotely piloted vehicles; International Conference, 5th, Bristol, England, September 9-11, 1985, Proceedings . Bristol, England, University of Bristol, 1985, p. 25.1-25.15.

Attention is given to the development history, design features and performance capabilities of a pneumatic catapult launching system for RPVs of up to 150 kg. The primary system components of the launcher are a pneumatic charge reservoir, a quick-opening valve, a pneumatic cylinder, a drive piston/carriage assembly, and a buffer. The system operates at less than 10-bar pressures, allowing a range of low cost pneumatic components to be used. O.C.

**A86-38069**
**DOUGLAS AUTOMATED WEIGHING SYSTEM**
C. R. SOLT, JR. (Douglas Aircraft Co., Long Beach, CA) IN: International Instrumentation Symposium, 31st, San Diego, CA, May 6-9, 1985, Proceedings . Research Triangle Park, NC, Instrumentation Society of America, 1985, p. 485-499.

The Douglas Automated Weighing System (DAWS), a new state-of-the-art system for weighing aircraft, is described. DAWS eliminates tedious manual weight calculations by using a computer. All aircraft data, platform data, load cell data, and setup configurations can be stored on a single disk. A truck provides portability, so that DAWS can be taken to the aircraft rather than vice versa. The DAWS hardware and software are described in this paper. C.D.

**A86-38070**
**A NEW APPROACH TO AUTOMATED GAS TURBINE ENGINE TESTING**
D. A. GRAVES and T. L. BORMAN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: International Instrumentation Symposium, 31st, San Diego, CA, May 6-9, 1985, Proceedings . Research Triangle Park, NC, Instrumentation Society of America, 1985, p. 501-524.

An automated gas turbine engine testing system, Test Stand (TS) 862, for unattended testing is described. The monitor and control system for TS 862 incorporates a Modvue industrial graphics processing system, three Intel single board computers, and a programmable controller. The Modvue system consists of a color monitor for display of engine parameters, and a second color monitor with a touch-sensitive screen for display of critical engine parameters and operator interface with engine testing. The new test system will provide greater safety for the engine by providing automatic engine shutdown. It will also reduce labor costs incurred when the engine cannot be run, by providing a detailed explanation of where the problems have occurred. Schematics and block diagrams are included. I.S.

**A86-38076*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**NATIONAL TRANSONIC FACILITY MACH NUMER SYSTEM**
F. A. KERN, C. W. KNIGHT, and R. F. ZASIMOWICH (NASA, Langley Research Center, Hampton, VA) IN: International Instrumentation Symposium, 31st, San Diego, CA, May 6-9, 1985, Proceedings . Research Triangle Park, NC, Instrumentation Society of America, 1985, p. 643-652.

The Mach number system for the Langley Research Center's National Transonic Facility was designed to measure pressures to determine Mach number to within + or - 0.002. Nine calibration laboratory type fused quartz gages, four different range gages for the total pressure measurement, and five different range gages for the static pressure measurement were used to satisfy the accuracy requirement over the 103,000-890,000 Pa total pressure range of the tunnel. The system which has been in operation for over 1 year is controlled by a programmable data process controller to select, through the operation of solenoid valves, the proper range fused quartz gage to maximize the measurement accuracy. The pressure gage's analog outputs are digitized by the process controller and transmitted to the main computer for Mach number computation. An automatic two-point on-line calibration of the nine quartz gages is provided using a high accuracy mercury manometer. Author

**A86-38228**
**INSTRUMENTATION AND TESTING TECHNIQUES IN THE T2 TRANSONIC CRYOGENIC WIND TUNNEL AT THE ONERA/CERT**
J. P. ARCHAMBAUD, A. BLANCHARD, and A. SERAUDIE (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 9-25. refs

In the T2 transonic wind tunnel considered, unconfined two-dimensional flow is obtained by moving solid top and bottom walls in the context of an iterative process, while the Reynolds number is increased by making use of cryogenic operation. The theoretical and practical principles involved in the employment of 'adaptive walls' are discussed. In a limited test section, unconfined flow around the model is established by controlling wall conditions, taking into account mass flow through slotted walls and changes in the shape of solid walls. Attention is given to control surface, real flow, virtual flow, the inverse mode, the employment of the Green transform with the Prandtl-Glauert rule, an adaptation flowchart, the constructional features of the T2 two-dimensional test section, and test results. Cryogenic models and their equipment are considered along with complementary instrumentation for flow measurements, and the results of measurements and calibrations. G.R.

**A86-38248**
**INSTRUMENTATION AND OTHER ISSUES IN NON-LINEAR DYNAMIC TESTING IN WIND TUNNELS**
E. S. HANFF, S. JENKINS, and A. PRINI (National Research Council of Canada, Ottawa) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 200-208. refs

The locally linearized aerodynamic model embodied in the stability derivatives formulation does not appear adequate to deal with severe nonlinear situations, such as encountered in flight at high angles of attack, and Hanff (1985) has proposed an approach for the representation of dynamic nonlinear aerodynamic reactions. The data needed for this approach can be obtained with the aid of an efficient wind-tunnel technique proposed by Hanff (1983). A summary of the principles of the wind-tunnel technique is presented, and an instrumentation system which has been implemented is briefly described. Attention is also given to a dynamic calibrator and its new electronic system, wind-tunnel apparatus, the representation of aerodynamic reactions, and aspects of simulation. G.R.

**A86-38252**
**A HOT AIR TUNNEL FOR BASE BLEED EXPERIMENTATION**
H. V. HATTINGH, D. VAN V. PIENAAR, and L. R. BOSCH (Stellenbosch, University, Republic of South Africa) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 233-240. refs

A thorough understanding of base bleed as applied to cannon shells to extend their range was to be obtained. After an evaluation of published information and approaches available to obtain such an understanding, it appeared to be essential to build a wind tunnel in which both the real stagnation pressure and the stagnation temperature could be simulated. On the basis of cost considerations, it was decided to provide a round test section of 150 mm. A range of Mach numbers and temperatures as a function of altitude had to be simulated. The Mach numbers were in the range from 3 (at sea level) to approximately 1 (barely supersonic). Direct heating was provided with the aid of a conduction heater. Attention is given to experimental equipment and experimental program. The relatively small effect of the rotational speed appears surprising. G.R.

**A86-38253**

**WIND TUNNEL FREE-FLIGHT TEST BY A VERTICAL DROP TECHNIQUE AT A HYPERSONIC MACH NUMBER OF 7**

K. HOZUMI (National Aerospace Laboratory, Tokyo, Japan) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 241-250. refs

As aerodynamic data obtained in a conventional wind tunnel are affected by the model support system, free-flight techniques are utilized to obtain data free from support-interference effects. An investigation was conducted regarding the practicability of the vertical drop method as a free-flight testing technique under hypersonic flow conditions. It was found that the employment of the considered method in a hypersonic wind tunnel with free-jet main flow provided a very useful and efficient approach to the acquisition of aerodynamic coefficients of bodies in motion having linear or nearly linear aerodynamic characteristics. Attention is given to the wind tunnel, the models, the test procedure, aspects of data reduction, a simulated data study, and a comparison between aerodynamic models. G.R.

**A86-38301**

**ALPHA JET TRAINING SYSTEM SINGLE AIRCRAFT CONCEPT**

C. A. BARENYI and G. BENATTI (Dornier GmbH, Friedrichshafen, West Germany) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p.
(SAE PAPER 851766)

The Alpha Jet Training System as a single aircraft concept consists of the training management system and media for the following: academics, simulators, and aircraft. It meets or exceeds all requirements for: (1) timely replacement of obsolete training system components, (2) effective and efficient management in the training of individual pilots, and (3) optimum employment of all components of the training system. It significantly lowers pilot training costs and personnel support requirements through the use of computer assisted instruction and procedure devices, the use of a training management system, and a modern high performance training aircraft with state-of-the-art simulators. Author

**A86-38319**

**GROUND TESTING APPROACH FOR THE B-1B BOMBER**

R. A. MORLEY (Teledyne Sprague Engineering, Gardena, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p.
(SAE PAPER 851796)

Existing methods for production ground testing of the B-1B would create an undesirable and cumbersome work environment. The noise generated by the equipment along with hoses, cables and ducts on the floor produce a safety hazard. The information presented here deals with a new approach to meet the aircraft delivery rate requirement. Goals were established and review of existing methods provided the 'stepping stones' to the solution. The use of high technology computer applications is discussed along with the equipment types used on the B-1B bomber. This is the first automated approach to ground testing and checkout of complex aircraft mechanical systems. Author

**A86-38370**

**LABORATORY SIMULATION OF LANDING GEAR PITCH-PLANE DYNAMICS**

J. J. ENRIGHT (BF Goodrich Co., Aerospace and Defense Div., Akron, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p. refs
(SAE PAPER 851937)

A technique for laboratory dynamometer simulation of landing gear-brake dynamics is discussed. The method was developed as a means of improving certain limitations of conventional dynamometer testing with and without actual strut hardware. The test fixture, the basis for its similitude, assumptions, and design criteria are described. Background includes descriptions of the form and significance of brake-induced vibration and the concept of a critical torque-speed slope as it relates to system stability criteria. Use of this fixture enables the duplication of brake squeal modes otherwise masked by standard dynamometer fixturing. The large linear range of amplitude and damping permit operation in a deliberately unstable condition to verify stability margins. Examples of the application and verification of the technique are included. Author

**A86-38371*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AIRCRAFT LANDING DYNAMICS FACILITY - A UNIQUE FACILITY WITH NEW CAPABILITIES**

P. A. DAVIS, S. M. STUBBS, and J. A. TANNER (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p.
(SAE PAPER 851938)

The Aircraft Landing Dynamics Facility (ALDF), formerly called the Landing Loads Track, is described. The paper gives a historical overview of the original NASA Langley Research Center Landing Loads Track and discusses the unique features of this national test facility. Comparisons are made between the original track characteristics and the new capabilities of the Aircraft Landing Dynamics Facility following the recently completed facility update. Details of the new propulsion and arresting gear systems are presented along with the novel features of the new high-speed carriage. The data acquisition system is described and the paper concludes with a review of future test programs. Author

**A86-39948*#** Massachusetts Inst. of Tech., Cambridge.

**EXPERIMENTAL MEASUREMENTS OF HEAT TRANSFER FROM AN ICED SURFACE DURING ARTIFICIAL AND NATURAL CLOUD ICING CONDITIONS**

M. S. KIRBY and R. J. HANSMAN, JR. (MIT, Cambridge, MA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 11 p. FAA-supported research. refs
(Contract NGL-22-009-640; NAG3-666)
(AIAA PAPER 86-1352)

The heat transfer behavior of accreting ice surfaces in natural (flight test) and simulated (wind tunnel) cloud icing conditions have been studied. Observations of wet and dry ice growth regimes as measured by ultrasonic pulse-echo techniques were made. Observed wet and dry ice growth regimes at the stagnation point of a cylinder were compared with those predicted using a quasi steady-state heat balance model. A series of heat transfer coefficients were employed by the model to infer the local heat transfer behavior of the actual ice surfaces. The heat transfer in the stagnation region was generally inferred to be higher in wind tunnel icing tests than in natural, flight, icing conditions. Author

**N86-26344#** Dayton Univ., Ohio.

**FLIGHT SIMULATOR: COMPARISON OF RESOLUTION THRESHOLDS FOR TWO LIGHT VALVE VIDEO PROJECTORS Final Report, Oct. 1984 - Aug. 1985**

P. M. CRANE, J. P. GERLICHER, and H. H. BELL Jan. 1986 15 p refs
(Contract F33615-78-C-0026; F33615-84-C-0066)
(AD-A164577; AFHRL-TP-85-43) Avail: NTIS HC A02/MF A01 CSCL 14B

The Air Force Human Resources Laboratory/Operations Training Division is developing a visual system for advanced tactical air combat simulators. As part of this work, two light valve video projectors were evaluated on their ability to display small, high-contrast images. The angular size of the smallest detail which could reliably be identified by an observer was determined for the General Electric PJ5155 and Sodern SVS-14 Video Projectors for stationary and moving targets under a variety of conditions. Several observers evaluated the projectors using variations of the stairstep procedure to determine minimum resolvable target size. For almost all conditions, observers were able to recognize smaller targets on the General Electric system than on the Sodern. With targets moving horizontally, however, minimum resolvable target size for the General Electric projector was significantly larger than for targets moving vertically or diagonally at the same speed. A hypothesis for this effect is discussed. Author (GRA)

**N86-26346#** Naval Postgraduate School, Monterey, Calif.
**ANALYZING THE COST EFFECTIVENESS OF USING FLIGHT SIMULATORS IN THE ISRAELI AIR FORCE M.S. Thesis**
U. ROZEN Dec. 1985 61 p
(AD-A164864) Avail: NTIS HC A04/MF A01 CSCL 05I

During the last decade flight simulators have been increasingly used in the training of Israeli pilots. The increasing cost of a training flying hour, the shrinking training airspace over Israel since 1979, and the high performance standards required of the Israeli Air Force air crews were the accelerator factors in this process. This thesis describes a way to analyze the cost effectiveness of the present mix of flight simulators and flying hours in the training process of the I.A.F. air crews. The jet fighters, helicopters, and transportation communities are used as examples to demonstrate the implementation of the analysis. These examples give the reader a general picture of the cost effectiveness of using flight simulators in the I.A.F. Author (GRA)

**N86-27291*#** Wichita State Univ., Kans. Dept. of Aeronautical Engineering.
**DE-ICING OF THE ALTITUDE WIND TUNNEL TURNING VANES BY ELECTRO-MAGNETIC IMPULSE Final Report**
G. W. ZUMWALT and R. ROSS Mar. 1986 79 p
(Contract NAG3-607)
(NASA-CR-177260; NAS 1.26:177260) Avail: NTIS HC A05/MF A01 CSCL 14B

The Altitude Wind Tunnel at the NASA-Lewis facility is being proposed for a refurbishment and moderization. Two major changes are: (1) the increasing of the test section Mach number to 0.90, and (2) the addition of spray nozzles to provide simulation of flight in icing clouds. Features to be retained are the simulation of atmospheric temperature and pressure to 50,000 foot altitude and provision for full-scale aircraft engine operation by the exhausting of the aircraft combustion gases and ingestion of air to replace that used in combustion. The first change required a re-design of the turning vanes in the two corners downstream of the test section due to the higher Mach number at the corners. The second change threatens the operation of the turning vanes by the expected ice build-up, particulary on the first-corner vanes. De-icing by heat has two drawbacks: (1) an extremely large amount of heat is required, and (2) the melted ice would tend to collect as ice on some other surfaces in the tunnel, namely, the tunnel propellers and the cooling coils. An alternate de-icing method had been under development for three years under NASA-Lewis grants to the Wichita State University. This report describes the electro-impulse de-icing (EIDI) method and the testing work done to assess its applicability to wind tunnel turning vane de-icing. Tests were conducted in the structural dynamics laboratory and in the NASA Icing Research Tunnel. Good ice protection was achieved at lower power consumption and at a wide range of tunnel operations conditions. Recommendations for design and construction of the system for this application of the EIDI method are given. Author

**N86-27293#** Washington Univ., Seattle. Transportation Center.
**USE OF NDE TO EVALUATE REFLECTION CRACKING IN AIRFIELD PAVEMENTS Final Report, Feb. - Aug. 1984**
D. E. NEWCOMB, J. P. MAHONEY, and J. SHARMA Nov. 1985 129 p
(Contract F08635-84-K-0145)
(AD-A164880; AFESC/ESL-TR-84-42) Avail: NTIS HC A07/MF A01 CSCL 14B

This study reports on the possible use of nondestructive testing equipment to evaluate the potential of reflection cracking in airfield pavements. It also summarizes the state of the art of reflection cracking analysis and methods for controlling reflection cracking. The proposed method of analysis consists of testing portland cement concrete slabs in a curled-up condition at slab centers and slab corners. Increased tensile strains at the bottom of the overlays at slab corners are related to the number of traffic repetitions to predict reflection cracking life. Although the method appears promising, further study is recommended to extend the limited data base presented here and gain added insight into the nature of mechanisms which cause reflection cracking. GRA

**N86-27294#** Illinois Univ., Urbana. Civil Engineering Lab.
**CONCEPTS FOR THE DEVELOPMENT OF A NONDESTRUCTIVE TESTING AND EVALUATION SYSTEM FOR RIGID AIRFIELD PAVEMENTS Final Report, Jan. 1983 - May 1985**
P. T. FOXWORTHY Nov. 1985 274 p Previously announced as N86-15324
(Contract F08637-84-M-1743)
(AD-A165055; AFESC/ESL-TR-85-46) Avail: NTIS HC A12/MF A01 CSCL 14B

This technical report develops a complete system for nondestructive testing and evaluation of rigid airfield pavements. An extensvie review of present destructive and nondestructive equipment and methodologies is made to form the basis for selection of the equipment and analytical model used in this research. A brief description of the selected Dynatest Model 8000 Falling Weight Deflectometer (FWD) and the ILLISLAB finite element computer model is presented. Three Air Force installations were chosen for in-depth study of pavement response to FWD loads under a variety of environmental and geological conditions. Techniques are presented to determine the location of maximum damage to rigid pavement slabs for one or any combination of aircraft, and the validity of the calculated stresses is established through comparisons of measured and predicted deflections at joints. Major study findings include: (1) new designations for pavement features based on actual loading conditions, (2) guidelines for planning and conducting large-scale evaluations of major airfield systems, (3) a computer-based determination of E and K, (4) joint behavior prediction under fluctuating temperatures and their effect on generated slab stresses, (5) procedures to account for the annual distribution of traffic over the range of temperatures normally experienced at any facility, and (6) a simplistic means of estimating total past damage from aircraft operations. Author (GRA)

**N86-27295#** Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
**VERIFICATION AND AERODYNAMIC CALIBRATION OF THE TUNNEL 16T CAPTIVE TRAJECTORY SUPPORT (CTS) SYSTEM Final Report, 21 Jul. - 26 Jul. 1985**
E. G. ALLEE, JR. and M. L. MILLS Mar. 1986 60 p Prepared in cooperation with Calspan Field Services, Inc., Arnold AFS, Tenn.
(AD-A165235; AEDC-TR-86-4) Avail: NTIS HC A04/MF A01 CSCL 14B

An air-on demonstration of the Captive Trajectory Support (CTS) system was conducted in the Propulsion Wind Tunnel (16T) on July 21 through July 26, 1985 The test objectives were: (1) to demonstrate the structural integrity of the CTS system; (2) to demonstrate the ability of the CTS system to satisfactorily obtain grid and trajectory generation data for a typical shore model in free stream and relative to a simulated (flat plate) aircraft in a dynamic wind tunnel environment; and (3) to obtain a Mach number calibration for the Tunnel 16T Cart 2 (Multi-Purpose Cart) with the CTS system installed. The 1/4-scale Maximum Volume Bomb (MVB) was used to represent a typical store. Data were obtained at free-stream Mach numbers from 0.3 to 1.6 at stagnation pressures from 400 to 1600 psfa. GRA

**N86-27296#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensbereich UT.
**DEVELOPMENT, CONSTRUCTION, AND MANUFACTURING OF WIND TUNNEL MODELS FOR AERODYNAMIC INVESTIGATIONS Final Report, Mar. 1984**
K. KASZEMEIK Bonn (West Germany) Bundesministerium fuer Forschung und Technologie Nov. 1985 50 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-85-012; ISSN-0170-1339; ESA-86-96887; TE-2-1363) Avail: NTIS HC A03/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 11

Models and model components for aerodynamic research in the European airbus project A-320 were manufactured with a numerical control milling machine and prepared for testing: Three high speed wings IFAS 5, 6, and 6.1; a low speed halfmodel with IFAS 6; a low speed complete model with IFAS 6; a halfmodel as test setup for high and low speed; an A-310 research model for the active tail-section design; and a propulsion simulator were produced. ESA

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# ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-38845#**
**OPTIMUM DESIGN OF LARGE STRUCTURES WITH MULTIPLE CONSTRAINTS**
R. A. CANFIELD, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 398-408. USAF-supported research. refs
(AIAA PAPER 86-0952)

Relative numerical efficiencies of different commonly used optimization techniques for solving problems with multiple constraints have been compared with an aim of developing an efficient optimization method for the automated design of large aerospace structures. A hybrid algorithm using both optimality criteria and mathematical programming methods is suggested. As a result of the study, the CONMIN computer program, and possibly NEWSUIT-A, will be used in conjunction with an optimality criteria algorithm built from OPTSTAT to develop the multidisciplinary hybrid optimization algorithm. I.S.

**N86-27351*#** National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
**PARTICULATE CONTAMINANT RELOCATION DURING SHUTTLE ASCENT**
J. J. SCIALDONE Jun. 1986 17 p
(NASA-TM-87794; NAS 1.15:87794; REPT-86B0432) Avail: NTIS HC A02/MF A01 CSCL 22B

The dislodgement, venting, and redeposition of particles on a surface in the shuttle bay by the vibroacoustic, gravitational, and aerodynamic forces present during shuttle ascent have been investigated. The particles of different sizes which are displaced, vented, and redistributed have been calculated; and an estimate of the increased number of particles on certain surfaces and the decrease on others has been indicated. The average sizes, velocities, and length of time for certain particles to leave the bay following initial shuttle doors opening and thermal tests have been calculated based on indirect data obtained during several shuttle flights. Suggestions for future measurements and observations to characterize the particulate environment and the techniques to limit the in-orbit particulate contamination of surfaces and environment have been offered. Author

**N86-27354#** Rockwell International Corp., Downey, Calif.
**OPERATIONAL FLIGHT EXPERIENCE AND DISASSEMBLY/INSPECTION RESULTS OF SPACE SHUTTLE ORBITER ACTUATORS**
D. WOOLHOUSE *In* ESA Second European Space Mechanisms and Tribology Symposium p 3-8 Dec. 1985
(Contract NAS9-14000)
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

After completion of the first six flights of Space Shuttle Columbia, the four rudder/speedbrake rotary actuators were removed so that a complete disassembly and inspection could be accomplished to evaluate the condition of all internal components. The flight loads experienced by the actuators are compared to those used in designing them. The combination of materials employed for the gear train and lubrication system of the Space Shuttle rudder/speedbrake rotary actuators successfully withstands all stresses and loads encountered during six orbital flights and six years of environmental exposure. Care should be exercised when choosing off-the-shelf or catalog parts (e.g., bearings, rollers, and spacers) to ensure that the same attention to surface protection is exercised as is typically given to custom designed parts. The requirement imposed on this design for operation during 100 missions over a 10 year period can be met as demonstrated by the excellent condition of these units after their flight exposure. ESA

**N86-27406*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**USERS GUIDE: STEADY-STATE AERODYNAMIC-LOADS PROGRAM FOR SHUTTLE TPS TILES**
P. A. KERR and D. H. PETLEY Jul. 1984 112 p
(NASA-TM-85724; NAS 1.15:85724) Avail: NTIS HC A06/MF A01 CSCL 22B

A user's guide for the computer program that calculates the steady-state aerodynamic loads on the Shuttle thermal-protection tiles is presented. The main element in the program is the MITAS-II, Martin Marietta Interactive Thermal Analysis System. The MITAS-II is used to calculate the mass flow in a nine-tile model designed to simulate conditions during a Shuttle flight. The procedures used to execute the program using the MITAS-II software are described. A list of the necessry software and data files along with a brief description of their functions is given. The format of the data file containing the surface pressure data is specified. The interpolation techniques used to calculate the pressure profile over the tile matrix are briefly described. In addition, the output from a sample run is explained. The actual output and the procedure file used to execute the program at NASA Langley Research Center on a CDC CYBER-175 are provided in the appendices. Author

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# CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-37708**

**ENVIRONMENTAL AND ADHESIVE DURABILITY OF ALUMINIUM-POLYMER SYSTEMS PROTECTED WITH ORGANIC CORROSION INHIBITORS**

L. J. MATIENZO, D. K. SHAFFER, W. C. MOSHJIER, and G. D. DAVIS (Martin Marietta Laboratories, Baltimore, MD) Journal of Materials Science (ISSN 0022-2461), vol. 21, May 1986, p. 1601-1608. refs
(Contract N00019-82-C-0439)

The protection of pretreated aluminium against environmental corrosion has been accomplished in varying degrees by incorporating selected organophosphonates and organosilanes on the metal surface. Ionizable phosphonates, such as nitrilo-tris methylene phosphonic acid (NTMP), adsorbed at monolayer concentrations, are effective inhibitors against hydration and are compatible with a nitrile-modified epoxy adhesive material. Aqueous 0.1 vol. pct solution of selected organosilane compounds containing reactive side chains (e.g. epoxy, mercapto) exhibit protection against both hydration corrosion and the action of an aggressive species (Cl) and provide good adhesive bond durability with both nitrile-modified and polyamide (primer) epoxy resin systems. Wedge test results suggest that the curing process (e.g. the percentage crosslinking) of the epoxy-polyamide primer system is not affected by the addition of organosilanes, but may be affected by NTMP. The results of substrate surface characterization, adsorption behavior of applied films, and evaluation of candidate inhibitors by chemical, mechanical, and electrochemical test methods are presented. Mechanisms to explain the observed behavior of the phosphonate and silane systems are discussed. Author

**A86-38266**

**AVIATION FUELS TECHNOLOGY**

E. GOODGER (Cranfield Institute of Technology, England) and R. VERE Basingstoke, England, Macmillan Publishers, Ltd, 1985, 278 p. refs

Current data on piston and turbine engines and aviation fuels are investigated. The procedures for the production, finishing processes, and storage of aviation gasolines and kerosines are examined. Methods for testing the composition, volatility, fluidity, combustion, corrosion, stability, and contaminants of fuels are discussed. The fuel characteristics within aircraft fuel systems and fuel combustion performance are analyzed. The development of aviation fuel from shale oil, tar, or coal, and the use of liquefied hydrocarbon gases, liquid hydrogen, hydrocarbon oxygenates, or hydrogen-nitrogen compounds as aviation fuel substitutes are studied. The fuels for ultra high performance aircraft and rocket propulsion are described. The application of electric, nuclear, or inertial propulsion, and biofuels to aircraft propulsion systems is proposed. I.F.

**A86-38309**

**EFFECTS OF SECTION THICKNESS AND ORIENTATION ON CREEP-RUPTURE PROPERTIES OF TWO ADVANCED SINGLE CRYSTAL ALLOYS**

M. DONER and J. A. HECKLER (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p. Research supported by the General Motors Corp.
(SAE PAPER 851785)

Effects of specimen thickness and orientation on creep and stress-rupture properties of two advanced single crystal alloys were investigated. The alloys were CMSX-3, a derivative of Mar-M247, and a new single crystal alloy, designated 'Alloy X', which is based on modification of IN-792 composition. Section thickness effects were ascertained utilizing four different specimen geometries, including 0.250-in. diameter bars and 0.020-in. thick specimens. The stress-rupture lives of both materials degraded with section thickness at stress levels less than 40,000 lb.sq in. The life degradation was approximately 3X at 20,000 lb/sq in. Investigations into the effects of orientation on stress-rupture properties indicated that, for Alloy X, the 110-oriented specimens suffered a loss of approximately 3X in stress-rupture lives, compared to 001-oriented specimens. On the other hand, essentially no difference was observed in the stress-rupture lives of 001and 110-oriented specimens of CMSX-3 alloy. Time for 1 percent creep was essentially unaffected by section thickness or orientation in both alloys. Author

**A86-38384**

**EVALUATION OF LESS TOXIC FUELS FOR AIRCRAFT EMERGENCY POWER SYSTEMS**

R. L. FISCHER (AiResearch Manufacturing Co., Torrance, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p.
(SAE PAPER 851974)

Fuel-oxidizer combinations are reviewed as alternates for monopropellant hydrazine for aircraft emergency power systems. Alcohol and oxygen, jet fuel and oxygen or air are evaluated. Author

**A86-38529**

**SOME ASPECTS OF FLUOROCARBON ELASTOMER COMPATIBILITY WITH GAS TURBINE LUBRICANTS**

J. W. A. PRAGNELL and J. VAN TILBORG (Castrol, Ltd., Pangbourne, England) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 33-57.
(SAE PAPER 851799)

Fluorocarbon elastomers in the form of 'O' ring seals, hoses, etc. are widely used in gas turbine engines and hence come into contact with lubricants approved for use in those engines. Reports of oil/fluorocarbon elastomer incompatibility have been made which have required investigation in order to determine why such problems occur. This paper deals with certain aspects of compatibility investigated by traditional test techniques and reveals some of the complexities of the problem. Author

**A86-38531**

**FORMULATING ADVANCED 4 CENTISTOKE GAS TURBINE OILS - A FEASIBILITY STUDY**

Q. E. THOMPSON and R. E. ZIELINSKI (Monsanto Industrial Chemicals Co., St. Louis, MO) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 69-75. refs
(SAE PAPER 851833)

A formulation study has been carried out to assess the feasibility of developing advanced gas turbine lubricants in the viscosity range intermediate between current MIL-L-7808 and MIL-L-23699 lubricants (4 centistokes). Using additive technology developed on advanced MIL-L-27502 oils, several 4-centistoke polyol ester-base stocks have been formulated. Eight of the blends thus far tested have shown good to acceptable performance in the Bearing Rig Test run under MIL-L-27502 conditions. Various other key targets of a proposed new specification have been met or closely approached. Author

**A86-38532**

### ADVANCED LUBRICANTS FOR AIRCRAFT TURBINE ENGINES

G. A. BEANE, IV (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH), L. J. GSCHWENDER, and C. E. SNYDER, JR. (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 77-94. refs
(SAE PAPER 851834)

An assessment of the performance of oils in Air Force turbine engines and helicopter gear boxes is presented along with predicted performance of current and upgraded military specification oils in advanced and 'growth' engine designs. Data is presented on advanced ester base oils evolving from current research efforts. Future high temperature candidate oils representing the ultimate stability for turbine engines are also discussed. Their use, in most cases, entails engine design considerations to accommodate their unique properties. The advantages and disadvantages of the various classes of synthetic oils for turbine engines are discussed, and deficiencies are identified where additional research programs are needed. Author

**A86-38534**

### ELECTROCHEMICAL EVALUATION OF CORROSIVITY IN TURBINE ENGINE OILS

L. STALLINGS, P. KENNEDY, N. REBUCK, and V. S. AGARWALA (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 103-108. refs
(SAE PAPER 851867)

This program involves the study of the factors associated with corrosion in turbine engine bearings. Turbine engine oil (MIL-L-23699) used in naval aircraft was found to absorb in excess of 2500 ppm of water at 25 C and 100 percent RH. A mineral oil will absorb in the range of 400 to 500 ppm. This absorbed water causes bearings lubricated with MIL-L-23699 oil to be susceptible to corrosion. A probe which consists of a series of electrochemical galvanic cells is being used to measure corrosion currents developed in high humidity salt air environments. This probe was developed to measure the corrosivity of the naval shipboard environment. Preliminary corrosion current curves have been developed with a bare probe and a probe coated with MIL-L-23699 turbine oil. Studies will be made with MIL-L-23699 base oil and various additives one at a time to determine the effect of each additive in the fluid on corrosion. Author

**A86-38535**

### THE INFLUENCE OF ESTERS ON ELASTOMER SEALS

G. VAN DER WAAL (Unichema, Netherlands) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 109-114.
(SAE PAPER 851868)

To ensure the flawless performance of gasturbine engines it is essential to have a full understanding of the influence of ester base fluids on elastomers, which are used as seals in these engines. This paper describes the development of a simple model to relate the chemical structure of ester base fluids and elastomer swell properties. It's validity has been checked experimentally using a variety of elastomer seals and lubricant base fluids. This model offers a guideline in the selection of esters for gasturbine engine oils, enabling current or new military and civilian specifications to be met. Author

**A86-38536**

### DEPOSITION IN GAS TURBINE OIL SYSTEMS. I - ANALYSIS AND CLASSIFICATION

D. G. DOWSE (Rolls-Royce, Ltd., Derby, England), E. JANSTEN (DFVLR, Cologne, West Germany), and K. MAIER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 115-131.
(SAE PAPER 851869)

Synthetic lubricants operating in today's gas turbine engines are often working to their limits in respect to thermal stability. Breakdown of these oils causes the formation of deposits in different areas of the engine oil system. Before action can be taken to minimize the deposition technology by either changes to formulation or design consideration it is important that the true nature of the deposit is examined. The results of an investigation of deposits taken from laboratory tests and engine environments are presented. These studies, conducted in a joint venture by the authors, attempt to characterize and classify the deposits in terms of their physical and chemical nature. Author

**A86-38538**

### THE INFLUENCE OF JFTOT OPERATING PARAMETERS ON THE ASSESSMENT OF FUEL THERMAL STABILITY

D. R. KENDALL and J. S. MILLS (Shell Research, Ltd., Thornton Research Centre, Chester, England) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 143-151. refs
(SAE PAPER 851871)

The performance of fuels in the Jet Fuel Thermal Oxidation Tester (JFTOT) has been compared with that in a simulated engine oil cooler. In an attempt to improve the poor correlation found between these tests, a carbon burn-off method has been developed to quantify the extent of deposition in the JFTOT and has been used to examine the influence of JFTOT operating conditions on fuel performance. This has shown that the poor correlation between the tests may be due to the low fuel flow rate and the use of aluminium (rather than stainless steel) test specimens in the standard JFTOT. Author

**A86-38539**

### EVALUATION OF JFTOT TUBE DEPOSITS BY CARBON BURNOFF

G. DATSCHEFSKI (ESSO Research Centre, Abingdon, England) and T. G. R. FARTHING (Rolls-Royce, Ltd., Bristol, England) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 153-158. Research supported by the Ministry of Defence (Procurement Executive). refs
(SAE PAPER 851994)

The Jet Fuel Thermal Oxidation Tester (JFTOT) is universally used to measure high temperature stability of aviation turbine fuels, which are pass or fail rated according to the amount of deposit formed on the heater tube, assessed by an optical reflectance method. A new quantitative tube rating method has been developed, in which the weight of deposit is determined by carbon burnoff. When applied to a series of test fuels, reasonable repeatability of results was obtained; it was also found that the magnitude of deposits at a given temperature varied with the type of fuel under test. Author

**A86-38822#**

**INGOT METALLURGY ALUMINUM - LITHIUM ALLOYS FOR AIRCRAFT STRUCTURE**

J. C. EKVALL and D. J. CHELLMAN (Lockheed-California Co., Burbank) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 203-209. refs
(AIAA PAPER 86-0890)

Material property and structural tests were performed on Lockalite (Al-2.1Li-2.5Cu-1.0Mg-0.13Zr) and two Al-Li-X commercial alloy samples, and the results are compared with the properties of 7075-T6X aluminum. The structural behavior was demonstrated by static tests conducted on tapered lugs, typical of those used in airframe applications. An analysis of failure mode criteria shows potential weight savings of 7 to 17 percent for individual Al-Li aircraft structural components and 9.5 percent for a fighter aircraft. It is concluded that Lockalite represents a suitable replacement for conventional 7075-T6X aluminum alloys. I.S.

**A86-38841#**

**COMPOSITE MATERIAL SERVICE EXPERIENCE ON BOEING COMMERCIAL AIRPLANES**

R. L. COGGESHALL (Boeing Commercial Airplane Co., Seattle, WA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 366-369.
(AIAA PAPER 86-0947)

The results of the NASA-sponsored flight evaluation program assessing the serviceability and the repair history of composite structures and parts installed on Boeing commercial aircraft are discussed. Typical composite applications include boron-epoxy foreflaps in B707, the B737 graphite spoiler, and the honeycomb sandwich panel of the B727 elevators. Graphite, Kevlar, and graphite-Kevlar composites are included in all flight control surfaces, fixed panels, and fairings in the B757, B767, and B737-300 latest generation aircraft. Concurrent with the design of these components, inspection, and repair requirements and procedures were developed to cover service-induced damage. I.S.

**A86-38859#**

**EFFECT OF CRACK GROWTH RATE VARIATIONS ON LIFE PREDICTIONS**

R. L. WILKINSON (USAF, Armament Div., Eglin AFB, FL) and R. M. ENGLE, JR. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 551-561. refs
(AIAA PAPER 86-0981)

In this paper, data from sixty-eight panels of 2024-T3 aluminum, all tested to identical conditions, were analyzed using the Walker equation to determine the statistical distribution of the crack growth rate constants, 'C' and 'N'. Using this analysis as a model of material property variation, fifteen combinations of maximum load and sequence were selected, and life predictions were made for each of twelve selections from the material properties distributions. Distributions of crack growth lives were determined, and the mean values were found to agree with a baseline deterministic life prediction within five percent. A regression analysis was also performed to determine life as a function of stress level and 'N' for the entire simulation of 180 trials. Agreement with the mean predicted lives was within 13 percent. Author

**A86-39617**

**FATIGUE BEHAVIOR OF TI-6AL-4V POWDER METALLURGY COMPACTS**

F. H. FROES, S. W. SCHWENKER (USAF, Materials Laboratory, Wright-Patterson AFB, OH), and D. EYLON (Metcut Research Associates, Inc., Metcut-Materials Research Group, Wright-Patterson AFB, OH) IN: 1985 Annual Powder Metallurgy Conference, San Francisco, CA, July 14-17, 1985, Proceedings . Princeton, NJ, Metal Powder Industries Federation, 1986, p. 519-530. refs
(Contract F33615-82-C-5078)

Good fatigue behavior is a major requirement for increased use of PM titanium components in airframe and gas turbine engine applications. The factors necessary to improve fatigue for both blended elemental (BE) and prealloyed (PA) components are discussed. In BE material the primary concern is to lower the level of salt contamination. For PA components, a low level of general contaminants, below the 50 micron level, is required. Recent work on microstructural modification in titanium PM material has resulted in fatigue strength superior to annealed ingot metallurgy products. These microstructure modifications have been achieved by either direct heat treatment or by thermochemical treatment, using hydrogen as a temporary alloying element. Author

**N86-26384#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**EVALUATION OF THE EFFECTS OF A PLASTIC BEAD PAINT REMOVAL PROCESS ON PROPERTIES OF AIRCRAFT STRUCTURAL MATERIALS Final Report, Oct. 1984 - Aug. 1985**

S. CHILDERS, D. C. WATSON, P. STUMPFF, and J. TIRPAK Dec. 1985 151 p
(AD-A165289; AD-F630715; AFWAL-TR-85-4138) Avail: NTIS HC A08/MF A01 CSCL 11D

An abrasive blasting process using plastic beads has been proposed for removing organic coatings from aircraft surfaces and component parts. During the prototype development of the plastic bead blasting process for paint removal many concerns surfaced relative to the potential effects of the process on metal and composite aircraft structural materials. This evaluation of the plastic bead blasting paint removal showed that it removed protective metal coatings such as aluminum cladding and anodize coatings from aluminum alloys and cadmium plating from steel structure. Surface roughness resulted on clad aluminum alloys. Warpage as a result of surface cold working occurred on unsupported thin skin metal materials. The bond strength of thin skin adhesive bonded structure was not affected. The process is less damaging in fatigue to 7075-T6 aluminum structure blasted at 60 psi nozzle pressure than at 38 psi nozzle pressure. Epoxy/graphite composite structure which was plastic bead blasted showed statistically significant losses in the matrix dominated properties. No significant reductions occurred in the fiber dominated mechanical properties. GRA

**N86-26429#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

**ENGINEERING PROPERTY COMPARISONS FOR 2324-T39 AND 2024-T351 ALUMINUM ALLOY PLATE**

L. SCHRA and W. G. J. THART 19 Mar. 1984 64 p
(Contract NIVR-1906)
(NLR-TR-84021-U; B8576225; ESA-86-96979) Avail: NTIS HC A04/MF A01

Engineering properties of the plate material of aluminum alloy 2324-T39 and alloy 2024-T351 were compared. Tensile strength, fracture toughness, notched fatigue strength, and the resistance to fatigue crack propagation under constant amplitude and flight simulation loading were considered. Significantly higher strength and fracture toughness properties are found for 2324-T39, but the notched fatigue strengths of both alloys are comparable. Fatigue crack propagation resistance of 2324-T39 is slightly better than 2024-T351 under constant amplitude loading, but less resistant under flight simulation loading. The latter result indicates that replacement of 2024-T351 by 2324-T39 in fatigue critical areas is questionable. ESA

**N86-26430#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
**EFFECTS OF CLADDING AND ANODIZING ON FLIGHT SIMULATION FATIGUE OF 2024-T3 AND 7475-T761 ALUMINUM ALLOYS**
R. J. H. WANHILL Jan. 1985 29 p refs
(Contract NIVR-1891)
(NLR-TR-85006-U; B8578427; ESA-86-96984) Avail: NTIS HC A03/MF A01

The effects of cladding and anodizing on flight simulation (gust spectrum) fatigue of notch specimens and riveted lap joints of 2024-T3 and 7475-T761 aluminum alloy sheet were investigated. Stress levels were chosen to provide long life data (100,000 simulated flights) for bare alloy specimens. Cladding and anodizing have very large effects on the fatigue lives. Cladding and anodizing are always detrimental for notched specimens. For lap joints, cladding is detrimental only combined with anodizing. Anodizing is very beneficial for lap joints to be assembled from bare alloy sheets. With equivalent surface treatments 2024-T3 specimens always have longer average fatigue lives than 7475-T761 specimens. ESA

**N86-26446#** Southwest Research Inst., San Antonio, Tex. Fuels and Lubricants Research Facility.
**HIGH-TEMPERATURE LUBRICATION SYSTEMS FOR RING/LINER APPLICATIONS IN ADVANCED HEAT ENGINES Interim Report, Oct. 1984 - Jul. 1985**
M. D. KANAKIA, E. C. OWENS, and M. B. PETERSON Jul. 1985 66 p Prepared in cooperation with Wear Sciences, Inc., Arnold, Md.
(Contract DAAK70-82-C-0001; DAAK70-85-C-0007)
(AD-A164955; BFLRF-189) Avail: NTIS HC A04/MF A01 CSCL 11H

An assessment of tribological requirements in upper cylinder area of advanced high temperature engines was made in terms of critical components and their operating conditions. The ring-liner applications are the most severe since they have high temperature (<800 F) and large number of sliding cycles 10 to the 8th power - 10 to the 10th power. This report explores and evaluates various high temperature tribological systems lubricants, materials and lubricant delivery or supply systems for high temperature ring-liner applications. Author (GRA)

**N86-27425#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
**IMPACT DAMAGE TO COMPOSITE STRUCTURES**
Feb. 1986 40 p
(AGARD-R-729; ISBN-92-835-1517-X) Avail: NTIS HC A03/MF A01

The impact of ballistic penetrators in fuel filled tanks generates high dynamic pressure loading. This damage process is generally referred to as hydraulic ram. Hydraulic ram in aircraft fuel tanks results in large damage of structural components, which in turn can lead to fuel loss or ingestion into the engines, fire and explosion. To determine the effect of hydraulic ram to an integral fuselage fuel tank with carbon/epoxy skin, a firing program was established. Plane carbon/epoxy plates, bolted to an impact box, were impacted with single cuboid fragments. Different shock-absorbing materials used to reduce hydraulic ram pressures on the impact plate, were investigated to prevent propagation of the shock wave. Multiple fragments were projected against the simulated fuel tank sections with carbon/epoxy skins and sandwich design at a hit density of 25 fragments per square meter. Author

**N86-27457#** Department of the Navy, Washington, D. C.
**NONSKID COATING FORMULATIONS Patent Application**
L. W. KRAFT and R. F. BRADY, inventors (to Navy) 22 Jan. 1986 15 p
(AD-D012186; US-PATENT-APPL-SN-621308) Avail: NTIS HC A02/MF A01 CSCL 01E

It is an object of the present invention to provide improved nonskid coating formulations having enhanced impact resistance and resistance to sliding movement thereon by aircraft or other equipment. It is a further object of the invention to provide nonskid coatings which will maintain their adhesion to primed steel after severe impact and thus eliminate the hazards caused by dislodged fragments. Yet another object of the invention is to provide nonskid coatings which are resistant to wear and which provide resistance to sliding throughout their service life by virtue of their coarse textured surface. The nonskid coating formulations of the present invention are comprised of two or more components that contain specified ingredients in specified amounts. The nonskid coating formulation is comprised of the following ingredients, by weight, 3 to 8% amine resins, 7 to 13% epoxy resins, 17 to 22% pigments, fillers, and thickeners, 10 to 20% solvents and 39 to 56% aggregates. GRA

**N86-27461#** Monsanto Co., Dayton, Ohio.
**PROPERTIES OF AIRCRAFT FUELS AND RELATED MATERIALS Final Report, 15 Feb. 1982 - 31 Jan. 1985**
D. S. DUVALL, A. D. SNYDER, J. HENRY, D. J. LEWIS, and F. N. HODGSON Aug. 1985 162 p
(Contract F33615-81-C-2035)
(AD-A164532; AFWAL-TR-85-2049) Avail: NTIS HC A08/MF A01 CSCL 21D

Fuel tests, analyses, and analytical method development were conducted on a number of fuels of an experimental nature in conjuction with ongoing Air Force programs for studying fuel combustion behavior, turbine engine design, and other fuel related technologies. Fuels from conventional and alternate sources were studied, as were fuels of the high density missile propellant type. A wide variety of both physical and chemical properties of the fuels were measured and are tabulated. Studies conducted to aid in the solution of operational problems are also reported. GRA

**N86-27465#** Du Pont de Nemours (E. I.) and Co., Aiken, S.C. Savannah River Lab.
**MULTISTAGE METAL HYDRIDE COMPRESSOR**
L. K. HEUNG 1986 14 p Presented at the Solid Storage Science and Engineering Meeting, Los Alamos, N. Mex., 12 Mar. 1986
(Contract DE-AC09-76SR-00001)
(DE86-001965; DP-MS-85-63; CONF-860345-1) Avail: NTIS HC A02/MF A01

Metal hydride compressors can compress hydrogen to high pressures without using mechanical moving parts. They are particularly suited for tritium applications because they require minimal maintenance. A three-stage metal hydride compressor which can compress hydrogen from 14.7 to 20,000 psia has been demonstrated. The design principle and experimental results are presented. DOE

# 12

# ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-37323**

**HOW US COMPANIES ARE ATTACKING PRODUCTION COSTS**

P. TURK Interavia (ISSN 0020-5168), vol. 41, April 1986, p. 419-423.

A comparative evaluation is made of the manufacturing costs-reduction impact of state-of-the-art aircraft materials and fabrication processes which combine automation with highly flexible process-control software. The techniques in question encompass both organic-matrix composites and novel metallic compositions; many have already been successfully applied in the construction of high performance military aircraft. Attention is given to the 'stealth technology'-related advantages of the novel automated fabrication technologies, and the most consequential characteristics of thermoplastic-matrix composites. O.C.

**A86-37348#**

**THE DYNAMIC INSTABILITY OF PLATE STRUCTURES**

H.-J. LIN and Y.-J. LEE (National Taiwan University, Taipei, Republic of China) Chinese Institute of Engineers, Journal (ISSN 0253-3839), vol. 9, Jan. 1986, p. 59-67. refs

The instability of plate structures subjected to in-plane periodic forces (e.g., buckling of ship decks and flat aircraft structures by winds storms) is analyzed using the finite element method. In the analysis, the mass matrix and the geometric stiffness matrix are introduced, and shear effects are taken into consideration. The eight-node isoparametric plate element and the three-node isoparametric beam element are applied in the analysis of regions of dynamic instability for plate, plate with a hole, stiffened plate, and beam. I.S.

**A86-37406#**

**VIBRATION TEST AND IDENTIFICATION OF MODAL PARAMETER OF AIRCRAFT WING MODEL**

Z. LI, Q. ZENG, and Z. WU Northwestern Polytechnical University, Journal, vol. 4, April 1986, p. 189-198. In Chinese, with abstract in English. refs

A value of 1 is assumed as the constant term in the denominator polynomial of a curve fitting rational-function polynomial and and employed to perform modal analysis of a scale model wing undergoing flutter. Experimental data were obtained by means of a vibration test featuring periodic, random signal excitation in a low speed wind tunnel. The experimental data were used to derive the frequency response function at 82 nodes. The analysis indicated that the coherence function approaches unity at frequencies near resonance. Sample data are provided from a determination of the vibration modes of two components of the wing model. The modes are shown to be in good agreement with those obtained with finite element method. M.S.K.

**A86-38224**

**RADAR DATA PROCESSING. VOLUME 2 - ADVANCED TOPICS AND APPLICATIONS**

A. FARINA and F. A. STUDER (Selenia S.p.A., Rome, Italy) Letchworth, England/New York, Research Studies Press, Ltd./John Wiley and Sons, Inc. (Electronic and Electrical Engineering Research Studies: Electronic Circuits and Systems Series, No. 3), 1986, 356 p. refs

The design and implementation of the radar data processing (RDP) theory are discussed. Data processing for netted monostatic and bistatic radar systems and technical problems such as the misalignment between radars and target altitude uncertainty are examined. The organization and display of the data on a computer system are studied. The computer simulation of tracking algorithms for RDP performance evaluation and the application of the simulation technique to monoradar and multiradar tracking algorithms are analyzed. The use of RDP in air-traffic control systems, maritime navigation surveillance, and defense systems is investigated. Computer requirements for the implementation of RDP algorithms are described. I.F.

**A86-38235*** High Technology Corp., Hampton, Va.

**COMPARISON OF HOT-WIRE MEASUREMENT TECHNIQUES IN A MACH 3 PILOT QUIET TUNNEL**

F.-J. CHEN (High Technology Corp., Hampton, VA) and I. E. BECKWITH (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 79-85. refs

Disturbance measurements were made in the free stream of a small Mach 3 quiet tunnel using constant-current and constant-temperature anemometers (CCA and CTA). Data from the two types of instruments are compared in terms of frequency response and normalized rms levels of mass flow fluctuations. The mode-diagram analysis of the CCA data produces reliable results because the frequency response is consistent for a wide range of overheat ratios. However, the mode-diagram results for the CTA data cannot be used due to the rapidly decreasing frequency response with decreasing overheat ratio. Only the mass flow fluctuations at high overheat ratio can be obtained with the CTA system, and they can be as much as 50 percent higher than those from the CCA system. Possible reasons for these measurement differences between the two systems are considered. Author

**A86-38236*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**DEVELOPMENT OF A TEMPERATURE-COMPENSATED HOT-FILM ANEMOMETER SYSTEM FOR BOUNDARY-LAYER TRANSITION DETECTION ON HIGH-PERFORMANCE AIRCRAFT**

H. R. CHILES and J. B. JOHNSON (NASA, Flight Research Center, Edwards, CA) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 86-91. Previously announced in STAR as N85-33121.

A hot-film constant-temperature anemometer (CTA) system was flight-tested and evaluated as a candidate sensor for determining boundary-layer transition on high-performance aircraft. The hot-film gage withstood an extreme flow environment characterized by shock waves and high dynamic pressures, although sensitivity to the local total temperature with the CTA indicated the need for some form of temperature compensation. A temperature-compensation scheme was developed and two CTAs were modified and flight-tested on the F-104/Flight Test Fixture (FTF) facility at a variety of Mach numbers and altitudes, ranging from 0.4 to 1.8 and 5,000 to 40,000 ft respectively. Author

**A86-38237**

**PULSED LASER LIGHT SHEET FLOW VISUALIZATION**

D. C. SOREIDE, G. D. DOUGLAS, and W. P. BRANDT (Boeing Commercial Airplane Co., Seattle, WA) IN: ICIASF '85 - International Congress on Instrumentation in Aerospace Simulation Facilities, 11th, Stanford, CA, August 26-28, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 100-105.

A pulsed ruby laser was used as light source for a set of flow visualization tests involving two test situations. In both cases, the conducted investigation was concerned with the location of the tip vortex of the rotor-blade of a helicopter, giving particular attention to the position relative to the following blade. The optical system employed is considered along with the electronics system, the setup equipment, and the helicopter test. Vortex field maps are provided for the case in which the helicopter rotor vortex field phase angle equals 0 degrees and for the case in which this angle equals 90 degrees. G.R.

**A86-38310*** AiResearch Casting Co., Torrance, Calif.

### FABRICATION OF CERAMIC COMPONENTS FOR ADVANCED GAS TURBINE ENGINES

F. LIU and E. SOLIDUM (AiResearch Casting Co., Torrance, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 12 p. DOE sponsored research. refs
(Contract DEN3-167)
(SAE PAPER 851786)

The AGT101 ceramic gas turbine engine feasibility study has made use of the slip casting of silicon or silicon nitride powders to produce either reaction-bonded or sintered components such as turbine rotors, turbine shrouds, and inner and outer diffusers. Attention is given to the effects of processing parameters on the microstructure and properties of the finished components; the parameters encompass powder particle size distribution, casting slip viscosity, pH, and solid content fraction. The green slip cast components were consolidated by nitriding, sintering, or sinter/HIPping. O.C.

**A86-38311*** AiResearch Casting Co., Torrance, Calif.

### PROCESSING STUDY OF INJECTION MOLDING OF SILICON NITRIDE FOR ENGINE APPLICATIONS

M. E. RORABAUGH and H. C. YEH (AiResearch Casting Co., Torrance, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p.
(Contract NAS3-24385)
(SAE PAPER 851787)

The high hardness of silicon nitride, which is currently under consideration as a structural material for such hot engine components as turbine blades, renders machining of the material prohibitively costly; the near net shape forming technique of injection molding is accordingly favored as a means for component fabrication. Attention is presently given to the relationships between injection molding processing parameters and the resulting microstructural and mechanical properties of the resulting engine parts. An experimental program has been conducted under NASA sponsorship which tests the quality of injection molded bars of silicon nitride at various stages of processing. O.C.

**A86-38318**

### MECHANICAL INTERFACE DEVICES FOR AUTOMATIC TEST EQUIPMENT

T. R. HESSEL (Grumman Corp., Bethpage, NY) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 8 p.
(SAE PAPER 851795)

This paper discusses interfaces to Automatic Test Equipment (ATE) for two engineering disciplines, optics and fluids. A detailed description of the development of an optical test port for ATE shows how this device functions with ATE to support a television tracking system. A description of a fluids interface highlights the diverse requirements for automatic testing. Author

**A86-38320**

### FLEXIBLE MANUFACTURING SYSTEM FOR THE FABRICATION OF PRECISION COMPONENTS WITH REAL TIME SIMULATION

H. R. GRAF (Hughes Aircraft Co., El Segundo, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 7 p.
(SAE PAPER 851804)

Real-time simulation for manufacturing decision support will soon become critical to the operation of flexible manufacturing systems. On unmanned systems, where many dissimilar parts are machined in random lot sizes to a high degree of precision, it is essential that the simulation model be continually updated by the system on the status of the product flowing through the system, as well as the status of equipment in the system. Real-time simulation will be a critical element in future computer integrated manufacturing systems. Author

**A86-38321**

### PROCESS FOR ADHESIVE BONDING OF METAL SKINS TO AIRCRAFT STRUCTURES

P. M. PHILLIPS (Murdock Engineering Co., Irving, TX) and S. C. AKER SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 9 p. refs
(SAE PAPER 851805)

A manufacturing process for the production of an adhesive bonded wet wing structure is described. The process involves: (1) the development of a laminated wing skins with bonded stringers subassembly; (2) the development of laminated skin to spar and rib subassembly; and (3) the bonding of the upper and lower skins. The advantages of bonded structures, which include lower weight, longer service life, and lower maintenance costs, are discussed. The surface preparation, adhesive films, and quality control for wing bonded structures are examined. The cost-effectiveness of bonded structures is analyzed. I.F.

**A86-38335*** Douglas Aircraft Co., Inc., Long Beach, Calif.

### THE DESIGN OF REPAIRABLE ADVANCED COMPOSITE STRUCTURES

L. J. HART-SMITH (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 17 p. refs
(Contract NAS1-11234; NAS1-13172; NAS1-16857; F33615-79-C-3212; F33615-80-C-5092)
(SAE PAPER 851830)

This paper addresses the repair of advanced composite structures by mechanical fasteners or by adhesive bonding. It is shown that many of today's composite designs are unreasonably difficult to repair. Conversely, the knowledge to design repairable structures is already available, if only it is applied during the initial design stage. Bolted or riveted repairs require only the avoidance of extremely orthotropic composite fiber patterns; those near the quasi-isotropic layup are the most suitable. Mildly orthotropic fiber patterns are appropriate for structures in which there is a dominant load direction. Thick composite structures are shown to require bolted or riveted repairs while thin structures favor adhesively bonded permanent repairs, although provisions can be easily made for temporary mechanical repairs. The reasons why integrally stiffened cocured composite designs are usually impractical to repair are explained and alternative repairable design concepts are presented. Author

**A86-38358**

### WAKE IMAGING SYSTEM APPLICATIONS AT THE BOEING AERODYNAMICS LABORATORY

O. P. CROWDER (Boeing Commercial Airplane Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 17 p. refs
(SAE PAPER 851895)

The wake imaging system (WIS) for rapid mappings of wind-tunnel model flowfields is described and a summary of recent results is presented. Three different types of systems are discussed. These are: (1) photographic WIS in low-speed wind tunnels, (2) computer graphics WIS in transonic wind tunnels, and (3) flying-strut traverser for large low-speed wind tunnels. In addition, progress toward developing a low intrusive WIS for high-pressure transonic wind tunnels and for flight test applications is described. Author

**A86-38522**

### A CEMENTITIOUS TOOLING/MOLDING MATERIAL - ROOM TEMPERATURE CASTABLE, HIGH TEMPERATURE CAPABLE

S. WISE and S. KUO IN: Composites: Design and manufacturing for general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 61-66.
(SAE PAPER 850904)

Dash 47R is a cementitious composite initially formulated for use as an autoclave molding/tooling material. A unique matrix and aggregate system imparts unusually high strength and excellent vacuum integrity to DASH 47 at moderately high temperatures even though DASH 47 molds are cast at ambient temperature over commonly used pattern materials. This paper reviews the formulation and properties of DASH 47, and outlines its fabrication method and curing schedule for thin-shelled autoclave tools. In addition, examples of other molding applications for DASH 47 are shown in this paper. Author

**A86-38523**

### GENERATION OF AN ELECTROFORMED NICKEL MOLD FOR USE IN MANUFACTURING COMPOSITE PARTS

D. L. SHELDON IN: Composites: Design and manufacturing for general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 16-19, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 67-69.
(SAE PAPER 850905)

Attention is given to the fabrication of electroformed nickel tools for use in the manufacture of composite parts, as well as the techniques used in the development of tools of this type. The method involves the electrodeposition of a metal onto a cathodic mandrel; the electrode is connected to a positive pole, while the mandrel is connected to the negative pole of a dc source. Two molds have been formed in this way for the wings of the AV-8B Harrier VTOL aircraft, representing the upper and lower wing contours. O.C.

**A86-38526**

### AVIATION GAS TURBINE LUBRICANTS - MILITARY AND CIVIL ASPECTS: AVIATION FUEL AND LUBRICANTS - PERFORMANCE TESTING; PROCEEDINGS OF THE AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985

Conference and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-633), 1985, 163 p. For individual items see A86-38527 to A86-38539.
(SAE SP-633)

Research and development programs in the areas of gas turbine lubricants for civil and military aviation and the performance testing of aviation gas turbine fuels and lubricants are discussed. The topics addressed include: laboratory and field evaluation of a high temperature jet engine oil, performance advantages of high load aviation lubricants, fluorocarbon elastomer compatibility with gas turbine lubricants, potential benefits in the development of a dedicated helicopter transmission lubricant, and feasibility of formulating advanced four centistoke gas turbine oils. Also covered are: advanced lubricants for aircraft turbine engines, future trends for U.S. Naval aviation propulsion system lubricants, electrochemical evaluation of corrosivity in turbine engine oils, the influence of esters on elastomer seals, deposition in gas turbine oil systems, development of the portable water separometer for the WSIM test, influence of JFTOT operating parameters on the assessment of fuel thermal stability, and evaluation of JFTOT tube deposits by carbon burnoff. C.D.

**A86-38527**

### DEVELOPMENT OF A HIGH TEMPERATURE JET ENGINE OIL - LABORATORY AND FIELD EVALUATION

H. L. HEPPLEWHITE, W. H. BUCK (Mobil Research and Development Corp., Paulsboro, NJ), and F. FEINBERG (Mobil Oil Corp., U.S. Marketing and Refining Div., Fairfax, VA) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1-17.
(SAE PAPER 851797)

Laboratory oxidation tests used to evaluate jet engine oils for stability and deposit control in several physical configurations are described. The use of these tests to formulate a new oil with enhanced capabilities at high temperatures is reported along with field evaluations which show performance benefits consistent with laboratory test results. A particular improvement has occurred in the number of oil-related engine removals. Additional improvements reported include cleaner engines, resulting in increased reliability of carbon seals, reduced oil consumption, improved engine reliability, and reduced maintenance. The results show that the laboratory tests can accurately discriminate among oils in terms of performance capability. C.D.

**A86-38528**

### PERFORMANCE ADVANTAGES OF HIGH LOAD AVIATION LUBRICANTS

D. S. BOSNIACK (Exxon Research and Engineering Co., Products Research Div., Annandale, NJ) and S. J. METRO IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 19-32.
(SAE PAPER 851798)

Aviation lubricants were extensively tested at severe conditions to determine the performance advantages of incorporating a load carrying additive. A high load oil performed at least as well or better than a normal load oil in the bearing rig test at Type 1 through Type 2-1/2 conditions. At the extremely severe Type 2-3/4 conditions, in an inerted atmosphere, all oils tested containing load carrying additives successfully completed the 100-hour test, while all oils tested without the additive suffered catastrophic failure in less than 10 hours. The role of the load carring additive in the protection of loaded, moving parts, as in the Ryder Gear Machine, was examined. Data for the anti-scuffing protection afforded by this additive through surface adsorption on working gears is presented. Author

**A86-38530**

### A STUDY OF THE POTENTIAL BENEFITS ASSOCIATED WITH THE DEVELOPMENT OF A DEDICATED HELICOPTER TRANSMISSION LUBRICANT

R. J. DRAGO (Boeing Vertol Co., Philadelphia, PA), P. J. MANGIONE, and R. D. WENDRZYCKI (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 59-68.
(SAE PAPER 851832)

A common oil is now used in both the engines and transmissions of virtually all U.S. military helicopters. While this provides significant logistic advantages, these advantages are attained only by compromising the optimization of the oil for either system. The results of two studies undertaken to determine what benefits would accrue to the development of a special oil tailored specifically to meet the unique requirements of high-speed, heavily loaded helicopter transmission systems are presented. These studies, conducted independently by two major helicopter manufacturers under the direction of the Naval Air Propulsion Center, addressed specific problem areas related to typical production aircraft in order to reach well-documented conclusions. In addition, the effect of the availability of such a special gear-box lubricant on the development of other advanced-technology components was evaluated and documented. Author

**A86-38533**

### FUTURE TRENDS FOR U.S. NAVAL AVIATION PROPULSION SYSTEM LUBRICANTS

J. T. SHIMSKI and L. A. PASKOW (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 95-102.
(SAE PAPER 851835)

Although present performance of aircraft gas turbine engine lubricants is satisfactory, two major areas have been targeted for improvement: static bearing corrosion and thermal stability of the oil. Trends in future engine designs indicate that waste heat rejection will be the limiting factor in the development of high temperature lubricants. Field experience has shown that present performance of aircraft gas turbine engine lubricants in helicopter gearbox systems is marginal. A three-phase program has been initiated to develop a separate lubricant with improved load-carrying capacity and corrosion inhibition. Future design requirements will have to incorporate new materials and lubricants concurrently. Author

**A86-38537**

### DEVELOPMENT OF THE PORTABLE WATER SEPAROMETER FOR THE WSIM TEST

P. W. KIRKLIN (Mobil Research and Development Corp., Paulsboro, NJ), F. R. EDMONDSON (EMCEE Electronics, Inc., Sarasota, FL), F. P. MORSE (USAF, Directorate of Energy Management, Kelly AFB, TX), and W. G. DUKEK IN: Aviation gas turbine lubricants - Military and civil aspects: Aviation fuel and lubricants - Performance testing; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 133-141. refs
(SAE PAPER 851870)

The water separation index, modified (WSIM) test, ASTM D2550, is used to indicate the presence of harmful levels of surface active agents (surfactants) in jet fuel. Many fuel suppliers, handlers and users have replaced the complex laboratory test, ASTM D2550, with a quick, simple test, ASTM D3948, that uses a compact, portable field test instrument, the Micro-Separometer. Results of co-operative ASTM test programs to develop the Micro-Separometer test are presented. The report shows that the Micro-Separometer produces the same water separation index as ASTM D2550 and that the test precision is equivalent or better. Author

**A86-38617*#** North Carolina State Univ., Raleigh.

### LINEAR DYNAMIC COUPLING IN GEARED ROTOR SYSTEMS

J. W. DAVID (North Carolina State University, Raleigh) and L. D. MITCHELL (Virginia Polytechnic Institute and State University, Blacksburg) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 108, April 1986, p. 171-176. refs
(Contract NSG-3239)
(ASME PAPER 85-DET-11)

The effects of high frequency oscillations caused by the gear mesh, on components of a geared system that can be modeled as rigid discs are analyzed using linear dynamic coupling terms. The coupled, nonlinear equations of motion for a disc attached to a rotating shaft are presented. The results of a trial problem analysis show that the inclusion of the linear dynamic coupling terms can produce significant changes in the predicted response of geared rotor systems, and that the produced sideband responses are greater than the unbalanced response. The method is useful in designing gear drives for heavy-lift helicopters, industrial speed reducers, naval propulsion systems, and heavy off-road equipment. I.S.

**A86-38831#**

### BUCKLING AND FINAL FAILURE OF GRAPHITE/PEEK STIFFENER SECTIONS

S. M. CAUSBIE (Boeing Commerical Airplane Co., Seattle, WA) and P. A. LAGACE (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 280-287. refs
(AIAA PAPER 86-0921)

The buckling and final failure characteristics of laminated angle and channel stiffener sections made of APC-2 graphite/thermoplastic material which employs PEEK fibers were investigated. Three stacking sequences with the same ply orientations were used in the experimental studies, the results of which were compared with buckling loads and modes estimated by use of the Ritz technique. Both the theoretical and experimental results indicate that buckling load decreases as (1) the side boundary conditions of the critical stiffener element become less restrictive; (2) the effective width/thickness ratio of the critical stiffener element is increased; (3) the bending stiffness term decreases; and (4) the bending-twisting coupling terms increase. The experimental results are similar to those obtained for similar sections made from T300/5208 graphite/epoxy material. I.S.

**A86-38833#**

### OBSERVATIONS ON COMPRESSIVE LOCAL BUCKLING, POSTBUCKLING AND CRIPPLING OF GRAPHITE/EPOXY AIRFRAME STRUCTURE

L. W. REHFIELD and A. D REDDY (Georgia Institute of Technology, Atlanta) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 301-306. Research supported by the United Technologies Corp. refs
(Contract DAAG29-82-K-0094)
(AIAA PAPER 86-0923)

Local buckling, postbuckling, and crippling of I-section composite specimens under axial compression were studied using high-speed photography. The specimens, representative of an airframe structure, were made of C3000/5225 graphite-epoxy woven cloth with five different web and flange ply layups. The results have shown that the critical failure mode is flange edge delamination followed by simultaneous failure of the flange and web. This finding implies that casual use of material strength criteria, without having a criterion for free edge delamination, may be misleading, and that multiple failure modes must be considered in order to reliably predict crippling. I.S.

**A86-38853#**

### STRENGTH EVALUATION OF HELICOPTER COMPOSITE BOLTED JOINTS

S. P. GARBO, S. W. HONG, and W. KIM (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 486-494. refs
(AIAA PAPER 86-0973)

Preliminary results of an analytical and experimental evaluation of the strength of bolted joints of three different composite systems considered for helicopter applications are reported. The three systems, carbon/epoxy tape, carbon/epoxy fabric, and carbon/bismaleimide laminates, were tested to failure using open-hole and bolt-bearing configurations, and stress-strain analysis was carried out for various hole-size geometries and bearing-bypass load conditions. Initial theory/test correlations successfully verified predicted failure modes and location of failure. Open-hole failure load predictions were used to establish a candidate characteristic dimension which was used to predict preliminary bypass vs bearing strength envelopes for the three material systems. For the application geometries tested, no significant differences in solutions due to geometry effects were determined. V.L.

**A86-38857*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**BUCKLING BEHAVIOR OF RENE 41 TUBULAR PANELS FOR A HYPERSONIC AIRCRAFT WING**

W. L. KO, R. A. FIELDS (NASA, Flight Research Center, Edwards, CA), and J. L. SHIDELER (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 517-544. refs

(AIAA PAPER 86-0978)

The buckling characteristics of Rene 41 tubular panels for a hypersonic aircraft wing were investigated. The panels were repeatedly tested for buckling characteristics using a hypersonic wing test structure and a universal tension/compression testing machine. The nondestructive buckling tests were carried out under different combined load conditions and in different temperature environments. The force/stiffness technique was used to determine the bucking loads of the panels. In spite of some data scattering resulting from large extrapolations of the data-fitting curve (because of the termination of applied loads at relatively low percentages of the buckling loads), the overall test data correlate fairly well with theoretically predicted buckling interaction curves. Also, the structural efficiency of the tubular panels was found to be slightly higher than that of beaded panels. Author

**A86-38876#**

**APPLICATION OF LOW TEMPERATURE CURING PREPREGS AND VACUUM BAG MOLDING TECHNIQUES TO THE MANUFACTURING OF A COMPOSITE WING**

E. AHOPELTO (Helsinki University of Technology, Espoo, Finland) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 695-699.

(AIAA PAPER 86-1019)

The design and development of a composite wing for the L-80 Turbo Trainer are described. The strength properties of the wing's graphite/epoxy materials are studied. The wing has a sandwich construction in order to provide sufficient stiffness with a minimum number of parts. Vacuum modeling techniques and low curing temperatures are utilized in the manufacturing of the upper and lower surface panels, main spar, leading edge, front and rear spars, and the wing ribs. The inspection of the reinforced plastic components is discussed. It is noted that the vacuum bag techniques are applicable for the manufacturing of all the large shallow parts of the composite wing; however, they are unsuitable for the development of complex structures such as wing ribs. I.F.

**A86-38878*#** Stanford Univ., Calif.

**AEROELASTIC TAILORING OF COMPOSITE WINGS WITH EXTERNAL STORES**

J. A. GREEN (Stanford University, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 710-719. refs

(Contract NGL-05-020-243)

(AIAA PAPER 86-1021)

The use of an integrating matrix solution procedure allows the aeroelastic stability of a large number of wing/store combinations to be studied with relative speed and accuracy. Results are presented which show the effects of tailoring the orientation of the plies of laminated composite wings when external stores are present. The stores utilized take the form of concentrated masses that are varied in terms of size and location, and combinations of stores are also studied. It is seen that there are cases for which small changes in the laminate can produce large changes in the aeroelastic stability boundary, and for such situations care should be used in tailoring a wing. For a given wing, the choice fiber angle to optimize the aeroelastic performance is quite sensitive to both the size and location of the store. Author

**A86-38934#**

**STOCHASTIC FLUTTER OF NONLINEAR AEROELASTIC STRUCTURES WITH PARAMETER RANDOM FLUCTUATIONS**

R. A. IBRAHIM (Texas Tech University, Lubbock) and H. HEO IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 533-543. refs

(Contract AF-AFOSR-85-0008)

(AIAA PAPER 86-0962)

The random response of nonlinear aeroelastic structural systems with time-dependent parameters is analyzed using recent developments in the mathematical theory of stochastic differential equations. In particular, the Ito stochastic calculus and the Fokker-Planck equation approach are used to derive a general differential equation which describes the evolution of the response moments. This equation constitutes an infinite coupled set of moment equations which are truncated by using two closure schemes. It is found that the random model interaction is governed mainly by the internal resonance ratio and the stiffness fluctuation intensity. The random variation of the system stiffness is shown to have a considerably greater effect on the system response than the random damping fluctuation. V.L.

**A86-38945*#** Old Dominion Univ., Norfolk, Va.

**EFFECTS OF NONLINEAR DAMPING ON RANDOM RESPONSE OF BEAMS TO ACOUSTIC LOADING**

C. MEI (Old Dominion University, Norfolk, VA) and C. B. PRASAD IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 644-653. refs

(Contract NAS1-17993)

(AIAA PAPER 86-1004)

Effects of both nonlinear damping and large-deflection are included in the theoretical analysis in an attempt to explain the experimental phenomena of aircraft panels excited at high sound pressure levels; that is the broadening of the strain response peak and the increase of the modal frequency. Two nonlinear damping models are considered in the analysis using a single-mode approach. Mean square maximum deflection, mean square maximum strain, and spectral density function of maximum strain for simply supported and clamped beams are obtained. It is demonstrated that nonlinear damping contributes significantly to the broadening of the response peak and to the mean square maximum deflection and strain. Author

**A86-38966**

**DEVELOPMENTS IN BOUNDARY ELEMENT METHODS - 4**

P. K. BANERJEE, ED. (New York, State University, Buffalo) and J. O. WATSON, ED. (Imperial College of Science and Technology, London, England) London and New York, Elsevier Applied Science Publishers, 1986, 356 p. For individual items see A86-38967 to A86-38971.

Recent developments in boundary element methods are discussed. New Hermitian cubic boundary elements are described which lead to better representations of boundary geometry and functions, particularly for fracture mechanics. A new advanced transient dynamic analysis for three-dimensional problems is presented, and stress analysis of axisymmetric bodies under nonaxisymmetric loading is discussed. A new plate bending formulation is presented in which a new class of fundamental solutions is developed which eliminates some of the problems related to strong singularities in a standard plate bending formulation. A novel application of the method to the nonlinear deformation analysis of sandwich plates and shallow shells is discussed. The first application of boundary element methods to problems of transient nonlinear heat transfer is described. A series of applications to some nonlinear geomechanics problems is presented in which the linear part of the region is modelled by boundary elements and the nonlinear region by finite elements. Recent developments in modelling fluid flow problems in the aircraft industry are surveyed. C.D.

**A86-39683**

### CHARACTERISTICS OF SYNTHETIC APERTURE RADARS [KHARAKTERISTIKI RADIOLOKATSIONNYKH STANTSII S SINTEZIROVANIEM]

N. A. SAZONOV Radiotekhnika (ISSN 0033-8486), April 1986, p. 28-31. In Russian.

Mathematical relations are derived for estimating the resolution and accuracy of azimuth determination by a synthetic aperture radar (SAR) under conditions of arbitrary motions of the flight vehicle and ground objects. The effect of motion parameters and phase fluctuations on the SAR characteristics is evaluated using the method of moments. V.L.

**A86-39979**

### PROCESSES FOR THE MANUFACTURE OF AVIATION INSTRUMENT COMPONENTS (2ND REVISED AND ENLARGED EDITION) [TEKHNOLOGIIA IZGOTOVLENIIA DETALEI AVIATSIONNYKH PRIBOROV /2ND REVISED AND ENLARGED EDITION/]

A. N. GAVRILOV Moscow, Izdatel'stvo Mashinostroenie, 1985, 232 p. In Russian. refs

The principles governing the design of processes for the manufacture of aviation instrument components are reviewed, as are the technical and economic characteristics of specific manufacturing processes. In particular, attention is given to the characteristic features of the production of aviation instruments, methods for the design of standardized manufacturing processes, production automation, and methods for the calculation and analysis of machining errors and tolerances. Other topics discussed include ways of increasing the reliability of aviation instruments at the stage of production, selection of an optimal process for the manufacture of specific components, and characteristics of processes for the manufacture of various types of components, including bushings, threaded parts, gears, permanent magnets, gyroscope components, and printed circuits. V.L.

**N86-26326#** Societe Francaise d'Instruments de Mesure, Velizy-Villacoublay (France). Secteur Capteur Optronique.

### USE OF A CO2 LASER LIDAR FOR FLIGHT AND PENETRATION AT VERY LOW ALTITUDES [UTILISATION D'UN LIDAR A LASER CO2 POUR LE VOL ET LA PENETRATION A TRES BASSE ALTITUDE]

B. STEPHAN *In* AGARD Guidance-Control-Navigation Automation for Night All-Weather Tactical Operations 8 p Oct. 1985
Avail: NTIS HC A07/MF A01

A CO2 laser optical sensor system which allows the acquisition of accurate land distances for a large area is described. These values are obtained in a real-time mode with the use of a UMP 7800 computer, and allow the generation of a map of the terrain to determine geographic coordinates. This map makes it possible to determine the optimal navigation trajectory at very low altitudes, with optimization based on the terrain features. This sensor was tested at Villacoublay in 1984 and is currently under testing at C.E.V. The results of the experiments and the static and dynamic analysis tests are presented. Transl. by T.R.

**N86-26480#** Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.

### COMPARATIVE STUDY OF NONDESTRUCTIVE PAVEMENT TESTING, WES (WATERWAYS EXPERIMENT STATION) NDT (NONDESTRUCTIVE TESTS) METHODOLOGIES Final Report

J. W. HALL and D. R. ALELXANDER Sep. 1985 66 p
(AD-A163379; WES-MP-GL-85-26) Avail: NTIS HC A04/MF A01 CSCL 13B

A demonstration of nondestructive airfield pavement evaluation procedures conducted by the US Army Engineer Waterways Experiment Station (WES) using both the WES 16-kip vibrator and a Dynatest falling weight deflectometer (FWD) is described. The nondestructive tests (NDT) were conducted at MacDill Air Force Base on five pavement test areas consisting of asphaltic concrete, portland cement concrete, and composite pavements. Two methods of data analysis were used. The dynamic stiffness modulus (DMS) method used dynamic deflection data from the WES 16-kip vibrator with a correlation analysis developed a number of years ago by WES. This method uses a correlation between the DSM (a load-deflection ratio) and the allowable load on a single wheel as derived from traditional test pit methods. The second analysis scheme used measured deflection basins at the pavement surface and layered elastic theory. Elastic moduli are computed by matching measured deflection basins with computed basins. Limiting stress/strain is then used to compute allowable aircraft loadings. This method was used with data from both the WES 16-kip vibrator and the FWD. Also demonstrated was a method of determining joint load transfer and of making appropriate adjustments to the allowable load to account for lack of load transfer. GRA

**N86-26501#** Human Engineering Labs., Aberdeen Proving Ground, Md.

### A COMPARISON OF VOICE AND KEYBOARD DATA ENTRY FOR A HELICOPTER NAVIGATION TASK Final Report

F. J. MALKIN and K. A. CHRIST Dec. 1985 42 p
(AD-A163245; HEL-TM-17-85) Avail: NTIS HC A03/MF A01 CSCL 17B

The Doppler navigation set, AN/ASN 128 was used to compare manual keyboard data entry of navigation map coordinates with an isolated-word speech recognition system. Twelve male Army aviators entered data by keyboard and by voice while controlling a helicopter flight simulator. The results indicated that although the keyboard mode was faster than the voice mode of data entry, the aviators preferred using voice. Voice data entry was perceived as requiring less effort and reducing pilot workload. However, the relative slowness and low accuracy (85.5 percent) of voice data entry highlight the limitations that may exist for speech recognition systems in performing time or task critical functions. GRA

**N86-26546*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Mechanical Engineering.

### THERMODYNAMIC EVALUATION OF TRANSONIC COMPRESSOR ROTORS USING THE FINITE VOLUME APPROACH Semiannual Status Report, 20 Dec. 1985 - 31 May 1986

S. NICHOLSON and J. MOORE 1986 81 p
(Contract NAG3-593)
(NASA-CR-176840; NAS 1.26:176840; JM/86-2) Avail: NTIS HC A05/MF A01 CSCL 20D

The finite volume explicit time marching method was refined and improved. Previously, extension had been made to the finite volume method to improve the accuracy of the calculation of total pressure in inviscid flow, extend the method to allow the calculation of laminar and turbulent boundary layers in internal flows, and improve the shock capturing properties of the method by introducing a Mach number dependent interpolation scheme for the pressure used in the calculating the density. The current work extends these developments by using the new pressure interpolation scheme in two dimensional viscous calculations, including a more complete description of the viscous stresses, introducing a criteria for the transverse upwind differencing which is a function of the ratio of transverse and streamwise mass fluxes, and allowing the calculation of internal flow where boundary layers are present on both walls of the duct. The manner in which the viscous stresses are evaluated in the nonorthogonal, nonuniform grid is detailed. The convergence is investigated and results for calculations of laminar flow in a converging duct are presented. Results for calculations of transonic flow in a converging-diverging nozzle are presented and the results are compared with Sajben's measurements and calculations by others. Author

**N86-26596*#** Sverdrup Technology, Inc., Cleveland, Ohio.
**CALIBRATION OF DROPLET SIZING AND LIQUID WATER CONTENT INSTRUMENTS: SURVEY AND ANALYSIS Interim Report**
E. C. HOVENAC May 1986 30 p refs Sponsored in part by FAA, Atlantic City, N.J.
(Contract NAS3-24105)
(NASA-CR-175099; E-3025; NAS 1.26:175099; FAA-CT-86-19)
Avail: NTIS HC A03/MF A01 CSCL 14B

Results are presented for phase 1 of an effort to establish a unified calibration capability for instruments used for aircraft icing certification and aircraft icing research. Various calibration, data correction, and verification procedures are reviewed and some new techniques are developed for droplet sizing instruments and liquid water content meters. These instruments include a forward scattering spectrometer probe, an optical array probe, and hot-wire type liquid water content meters. Work planned for phase 2 of the effort is described. Author

**N86-26603#** Calspan Advanced Technology Center, Buffalo, N.Y.
**AN EVALUATION OF THE CAPABILITY OF THE SURFACE CONDITION ANALYZER (SCAN) SENSORS TO MEASURE RUNWAY WATER DEPTH Final Report, Mar. 1981 - Jan. 1986**
C. W. ROGERS, E. J. MACK, and B. J. WATTLE Jan. 1986 58 p
(Contract N00014-81-C-0443)
(AD-A164719; CALSPAN-6857-M-1) Avail: NTIS HC A04/MF A01 CSCL 14B

Field tests of Surface Systems, Inc.'s Surface Condition Analyzer's (SCAN) capability to measure runway water depth during rainfall events were performed at the Spirit of St. Louis Airfield, St. Louis, Mo., during March-May of 1985. These limited tests were scheduled to provide data in real rainfall events and to answer questions of sensor capability relative to true runway water depth and or sensor installation and siting protocol--i.e., should the sensor surface be horizontal or flush relative to a sloping runway surface. Field calibration checks showed that sensors installed in the runway surface can measure in-situ water depth in the range 0.030 to 0.40 inches (+ or = 0.01 inches). In real rainfall with rates ranging from 0.30 inches/hour (very light) to 6.0 inches/hour (heavy), it was found that the sensor-measured water depth correlated very well with an independently measured water depth over the range 0.03 to 0.10 inches (maximum observed). At the lower end of this range, both sensors measured the same water depth, while at the top end, the sloping, flush-mounted sensor indicated only about 75% of the water depth measured independently and by the horizontally mounted sensor. GRA

**N86-26629*#** Garrett Turbine Engine Co.. Phoenix, Ariz.
**PRELIMINARY EVALUATION OF A COMPOUND CYCLE ENGINE FOR SHIPBOARD GENSETS**
J. G. CASTOR and W. T. WINTUCKY (National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.) Jun 1986 29 p Sponsored by NASA. Prepared in cooperation with Naval Ship Research and Development Center, Annapolis, Md. Development Center, Annapolis, Md.
(Contract NAS3-24346)
(NASA-CR-179451; NAS 1.26:179451; DTNSRDC-PASD-CR-1886; GARRETT-21-5869; AVSCOM-TR-86-C-20) Avail: NTIS HC A03/MF A01 CSCL 13I

The results of a thermodynamic cycle (SFC) and weight analysis performed to establish engine configuration, size, weight and performance are reported. Baseline design configuration was a 2,000 hour MTBO Compound Cycle Engine (CCE) for a helicopter application. The CCE configuration was extrapolated out to a 10,000 MTBO for a shipboard genset application. The study showed that an advanced diesel engine design (CCE) could be substantially lighter and smaller (79% and 82% respectively) than todays contemporary genset diesel engine. Although the CCE was not optimized, it had about a 7% reduction in mission fuel consumption over today's genset diesels. The CCE is a turbocharged, power-compounded, high power density, low-compression ratio diesel engine. Major technology development areas are presented. Author

**N86-26653*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**BUCKLING BEHAVIOR OF RENE 41 TUBULAR PANELS FOR A HYPERSONIC AIRCRAFT WING**
W. L. KO, J. L. SHIDELER, and R. A. FIELDS May 1986 31 p refs Presented at the AIAA/ASME/ASCE/AHS 27th Structures, Structural Dynamics and Materials Conference, San Antonio, Texas, 19-21 May 1986
(NASA-TM-86798; H-1327; NAS 1.15:86798; AIAA-86-0978)
Avail: NTIS HC A03/MF A01 CSCL 20K

The buckling characteristics of Rene 41 tubular panels for a hypersonic aircraft wing were investigated. The panels were repeatedly tested for buckling characteristics using a hypersonic wing test structure and a universal tension/compression testing machine. The nondestructive buckling tests were carried out under different combined load conditions and in different temperature environments. The force/stiffness technique was used to determine the buckling loads of the panel. In spite of some data scattering, resulting from large extrapolations of the data fitting curve (because of the termination of applied loads at relatively low percentages of the buckling loads), the overall test data correlate fairly well with theoretically predicted buckling interaction curves. Also, the structural efficiency of the tubular panels was found to be slightly higher than that of beaded panels. Author

**N86-26661#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
**THE POSTBUCKLING BEHAVIOR OF BLADE-STIFFENED CARBON EPOXY PANELS LOADED IN COMPRESSION**
J. F. M. WIGGENRAAD 19 Feb. 1985 20 p
(Contract NIVR-312.2-1019)
(NLR-MP-85019-U; B8577052; ESA-86-96977-L) Avail: NTIS HC A02/MF A01

The postbuckling behavior of blade-stiffened carbon epoxy panel laminates consisting of only a few layers due to the relatively low design loads was studied in compression tests. Certain coupling terms in the stiffness matrices were thought to be no longer insignificant. The full scale panels buckle in a global mode and do not show any postbuckling strength. The short columns, buckling in a local mode, support 1.8 times the initial buckling load before failure. Comparison with calculations shows that the influence of the coupling terms on the buckling behavior of the specimens is relatively small: it decreases the buckling load slightly, does not change the end shortening curves significantly and is mainly apparent in the out-of-plane deflections. ESA

**N86-26662#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
**SOME TESTS TO ASSESS THE EFFECT OF CRACK STOPPERS ON THE FATIGUE LIFE OF CENTER-NOTCHED SPECIMENS**
J. SCHIJVE and F. A. JACOBS Feb. 1984 33 p refs
(NLR-TR-84051-U; B8576224; ESA-86-96981) Avail: NTIS HC A03/MF A01

Crack stoppers were evaluated in crack propagation tests on Alclad 2024-T3 sheet specimens (thickness 2 mm) provided with a central crack to assess the usefulness of very simple crack stopping elements which can be applied to macrocracks in sheet metal structures accessible from one side only. Results show that a stop hole at the crack tip should be filled to obtain a good propping of the hole. Self tapping screws and tapered pins give large crack growth retardation lives. Large retardations are obtained with hard driven rivets and with heavily tightened bolts in the stop holes, but they require accessibility from two sides. Flight-simulation loading on specimens with tightened bolts indicates a significant retardation, but quantitatively the effects under flight-simulation loading and under constant-amplitude loading are highly different. ESA

**N86-26663#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

**CONSTANT AMPLITUDE AND FLIGHT SIMULATION OF FATIGUE TESTS ON ADHESIVE BONDED LAP JOINT SPECIMENS OF 2024-T3 SHEET MATERIAL**

J. SCHIJVE and F. A. JACOBS 9 Aug. 1984 47 p refs
(Contract NIVR-1725)
(NLR-TR-84090-U; B8576223; ESA-86-96982) Avail: NTIS HC A03/MF A01

Fatigue tests were carried out on Redux and FM 123/5 bonded specimens at various stress levels, temperatures (RT to 65C) and low and high test frequencies. Type of failure (bond line failure or sheet failure) and the significance of the adhesive squeeze-out for crack nucleation were examined. Results indicate that the fatigue notch effect of a thickness increase as a result of adhesive bonding of sheet material is very small; the effect of secondary bending is more significant. If the bending effect is not excessive (depending on the design) the fatigue strength of a bonded lap joint is high. In flight-simulation tests, bond line failures do not occur even under severe test conditions. The life in flight is highly superior to results for riveted lap joint and a single shear strap joint, while it is of the same order of magnitude found for riveted double-strap joints. ESA

**N86-27219#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

**A VORTEX POINT METHOD FOR CALCULATING INVISCID INCOMPRESSIBLE FLOWS AROUND ROTARY WINGS**

B. CANATLOUBE and S. HUBERSON *In its* La Recherche Aerospatiale. Bimonthly Bulletin, no. 1984-6, November - December 1984 (ESA-TT-907) 13 p May 1985 Previously announced in IAA as A86-12021
Avail: NTIS HC A04/MF A01; HC also available in English and French from ONERA, Paris FF 70

An integral method is presented for calculating incompressible inviscid unsteady flow around thin bodies in arbitrary motion, i.e., rotor blades in motion with respect to one another. Because an integral method is used, discretization is limited to the solid boundaries and the vortices. Boundary conditions are treated in terms of equation for the slipstream on the walls, the vorticity vector, a volume integral for the vorticity and a first-order Fredholm integral. The Helmholtz equation governs the evolution of vorticity, which forms a sheet of doublets. The pressure jumps on the blades are covered by the unsteady Bernoulli equation. Applications of the method to helicopter rotors, medium- and high-aspect ratio propellers and low-aspect ratio nautical propellers are demonstrated. M.S.K. (IAA)

**N86-27467*#** National Aeronautics and Space Administration. Pasadena Office, Calif.

**OXYGEN CHEMISORPTION CRYOGENIC REFRIGERATOR Patent Application**

J. A. JONES, inventor (to NASA) (Jet Propulsion Lab., California Inst. of Tech., Pasadena) 24 Apr. 1986 15 p Sponsored by NASA
(NASA-CASE-NPO-16734-1-CU; NAS 1.71:NPO-16734-1-CU; US-PATENT-APPL-SN-855982) Avail: NTIS HC A02/MF A01 CSCL 13I

The present invention relates to a chemisorption compressor cryogenic refrigerator which employs oxygen to provide cooling at 60 K to 100 K. The invention includes dual vessels containing an oxygen absorbent material, alternately heated and cooled to provide a continuous flow of high pressure oxygen, multiple heat exchangers for precooling the oxygen, a Joule-Thomson expansion valve system for expanding the oxygen to partially liquefy it and a liquid oxygen collection vessel. The primary novelty of the present invention lies in the provision of a refrigeration system which makes use of reversible chemical reactions with oxygen to provide cooling at 60 K to 100 K. NASA

**N86-27468#** Shock and Vibration Information Center (Defense), Washington, D. C.

**THE SHOCK AND VIBRATION DIGEST, VOLUME 18, NO. 1 Monthly Report**

J. NAGLE-ESHLEMAN, ed. Jan. 1986 116 p
(AD-A165726) Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

Topics addressed include: mechanical systems, analysis and design, structural systems, vehicle systems, biological systems, mechanical components, structural components, electric components, dynamic environment, mechanical properties, and experimentation. Literature review of the behavior of elastomeric material under dynamic loads and rotor instability in centrifugal pumps is also presented.

**N86-27471#** Shock and Vibration Information Center (Defense), Washington, D. C.

**THE SHOCK AND VIBRATION DIGEST, VOLUME 17, NO. 8 Monthly Report**

J. NAGLE-ESHLEMAN, ed. Aug. 1985 117 p
(AD-A165115) Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

Topics adressed include mechanical systems, structural systems, vehicle systems, biological systems, mechanical components, electric components, structural components, analysis and design, dynamic environment, mechanical properties, and experimentation. Literature on noise transmission into propeller aircraft is reviewed. Computer automated failure predictions in mechanical systems are discussed.

**N86-27624#** Royal Netherlands Aircraft Factories Fokker, Amsterdam.

**PRINCIPLES AND APPLICATIONS OF THE FOKKER BOND TESTER**

J. J. C. CAARLS, R. J. QUERIDO, and A. G. JULIER 1985 21 p Presented at Air Transport Association of America Nondestructive Testing Forum, Miami, Fla., 17-20 Sep. 1985
(Contract BMFT-0101-ZA/WF/WRD-174/4)
(ESA-86-96960) Avail: NTIS HC A02/MF A01

An instrument for testing adhesive bonding of aircraft structures is described. Factors determining bond strength; principle of operation; and the use of correlation charts are discussed. Automation and improvements to the instrument since its introduction are outlined. ESA

**N86-27630*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**OPTIMIZED BOLTED JOINT Patent**

L. J. HART-SMITH (McDonnell-Douglas Corp., Long Beach, Calif.), B. L. BUNIN, and D. J. WATTS, inventors (to NASA) 1 Apr. 1986 9 p Filed 23 Jan. 1984 Supersedes N84-20859 (22 - 11, p 1664) Sponsored by NASA. Langley Research Center
(NASA-CASE-LAR-13250-1; US-PATENT-4,579,475; US-PATENT-APPL-SN-573162; US-PATENT-CLASS-403-312; US-PATENT-CLASS-403-388; US-PATENT-CLASS-403-408.1)
Avail: US Patent and Trademark Office CSCL 13I

A method is disclosed for joining segments of the skin of an aircraft. The ends of the skin are positioned in close proximity or abutt each other. The skin is of constant thickness throughout the joint and is sandwiched between splice plates, which taper in thickness from the last to the first bolt rows in order to reduce the stiffness of the splice plate and thereby reduce the load transfer at the location where bypass loads are the highest.

Official Gazette of the U. S. Patent and Trademark Office

**N86-27632#** Rolls-Royce Ltd., Derby (England).
**DESIGN, DEVELOPMENT AND OPERATION OF A HIGH SIMULTANEOUS CAPACITY DIGITAL TELEMETRY SYSTEM**
K. BRADLEY *In* Von Karman Inst. for Fluid Dynamics Measurements Techniques in Turbomachines, Volume 2 32 p 1985
Avail: NTIS HC A17/MF A01

A digital telemetry system for measuring pressures in interblade passages on large fan engines and model fan rigs was developed. The telemetry system replaces the slip-rings used in previous tests, and incorporates on rotor digitization and hybrid circuit techniques. Simultaneous cpacity is 48 measurements, in the dc to 3 kHz bandwidth. Measurement accuracy is + or - 0.5% fsd (dc) to 1.0% fsd (ac). Dynamic range is 60 dB. Input sensitivity is 0 to 80 mV for 0 to 25 psia. Applications are to an RB 211 development engine and a model scale fan rig. Engine shaft speed is 3900 rpm, rig speed is 10,000 to 11,000 rpm. Author (ESA)

**N86-27678#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**STATIC AEROELASTICITY IN COMBAT AIRCRAFT**
Jan. 1986 42 p
(AGARD-R-725; ISBN-92-835-1516-1) Avail: NTIS HC A03/MF A01

A review of fighter aircraft development programs over the past three decades indicates a trend of increasing emphasis on the consideration of static aeroelastic effects. While early concerns addressed only the impact on air vehicle structural integrity, current design philosophy recognizes and addresses aeroelasticity as a primary design parameter affecting structural optimization, vehicle aerodynamic stability, control effectiveness, and overall performance. Examples from wind tunnel testing, analytical studies, and operational applications are presented to justify this emphasis, illustrate current methodology and analysis techniques, and make a case for an integrated approach to the consideration of static aeroelastic effects at all stages of the design process. Author

# 13

# GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-37451**
**INTERNATIONAL CONFERENCE ON THE AVIATION WEATHER SYSTEM, 2ND, UNIVERSITE DU QUEBEC, MONTREAL, CANADA, JUNE 19-21, 1985, PREPRINTS**
Conference sponsored by the American Meteorological Society, Canadian Meteorological and Oceanographic Society, ICAO, and WMO. Boston, MA, American Meteorological Society, 1985, 388 p. For individual items see A86-37452 to A86-37512.

The present conference considers weather forecasters' liability for inaccurate forecasts, the ICAO's World Area Forecast System, the FAA's future aviation weather system and its current Automated Weather Observing System, aircraft icing observation and analysis, the unified message switch and its application to aviation weather support, the hazards of ash clouds to civil air transport, NASA storm hazards research in lightning strikes to aircraft, and terrain-induced wind shear as the possible cause of the Jetstar N520S accident. Also discussed are the uncertainty of visibility measurements in radiation fog, challenges for clear air turbulence research, modernization of weather support for NASA's STS, the 'nowcasting' of rain, freezing rain and thunderstorms, the numerical simulation of precipitation-induced downbursts, and the role of thermodynamic effects in severe downdrafts. Attention is finally given to the USAF Automated Weather Distribution System, technological improvements to Naval Aviation weather support, a meteorological interactive data display system, and weather research and logistics at Cape Canaveral. O.C.

**A86-37454**
**THE SAFETY AND ECONOMIC IMPACT OF IMPROVED AVIATION WEATHER SERVICES**
J. W. HINKELMAN, JR. (NOAA, PROFS Program Office, Boulder, CO) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 29-40. refs

Flight safety and operational efficiency in both en route and terminal airspace are expected to be substantially enhanced by the novel Aviation Weather System. These improvements will be due to improved radar detection, identification and tracking, more automated surface observations, the automation of upper air observations by means of a national profiler system, and the automated collection/processing/distribution of pilot reports. Automation will also allow the tailoring of weather data for direct operational application, and could provide real-time hazardous weather avoidance assistance to pilots. O.C.

**A86-37456**
**NMC PLANS FOR IMPROVED AVIATION GUIDANCE**
J. A. BROWN, JR., R. D. MCPHERSON, and J. P. GERRITY, JR. (NOAA, Development Div., Washington, DC) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 44-47.

The numerical weather forecasting efforts of the U.S. National Meteorological Center are focused on the use of the Class VI CYBER 205 computer. A totally revised Regional Analysis and Forecast System was introduced into the operational production schedule in 1985; more recently, the global forecasting system was revised to separate the Medium Range Forecast guidance for 3-10 day intervals from the twice-daily global forecasts (which primarily address international aviation requirements). In both cases, significant forecast improvements have been achieved. O.C.

**A86-37458**
**THE FEDERAL AVIATION ADMINISTRATION FUTURE AVIATION WEATHER SYSTEM**
E. MANDEL (FAA, Washington, DC), M. MANN (Martin Marietta Corp., Washington, DC), and J. KEFALIOTIS (Stanford Telecommunications, Inc., Washington, DC) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 55-62.

The National Airspace System's weather system upgrading effort attempts to ensure the availability of adequate weather data to pilots, in the interest of hazard avoidance and effective traffic flow planning. Dramatic improvements have been made by this program in such areas as weather sensors, data processing, and weather display/distribution systems. Attention is given to the Next Generation Weather Radar, the Automated Weather Observing System, the Low Level Windshear Alert System, Runway Visual Range systems, and the Airport Surveillance Radar Weather channel 'ASR-9'. O.C.

**A86-37459**
**THE FAA AUTOMATED WEATHER OBSERVING SYSTEM (AWOS)**
R. H. CHRISTIANSEN and F. E. GILK (Kentron International, Inc., Arlington, VA) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 63-68.

The FAA's Automated Weather Observing System (AWOS) will furnish weather parameters to pilots, during takeoff and landing phases of flight, and ATC personnel, for the management of a given ATC zone. At a minimum, AWOS will detect and report wind speed and direction, temperature, dew point, pressure, cloud cover and height, and precipitation. Computer generated voices over telephones and ground-air radios will both be used for AWOS data distribution, and its digitized weather observation data will be transmitted over various data links to the National Weather Network. O.C.

**A86-37460**

**AUTOMATION OF SURFACE OBSERVATIONS PROGRAM**

S. E. SHORT (NOAA, National Weather Service, Silver Spring, MD) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 69-75.

A prospective performance assessment is presented for the nationwide implementation of Automated Surface Observing Systems (ASOS). Two ASOS capability levels are planned: a basic level system for the automatic observation of aviation operations-supporting weather parameters, and a more completely automated stand-alone system for observing and reporting the full range of weather parameters. About 250 ASOS units are scheduled for operation by the end of the 1980s, at nearly all current National Weather Service primary observation sites; the majority of these will initially be basic systems, but most will ultimately be enhanced to full automation as the necessary sensors become available. O.C.

**A86-37461**

**THE FAA/M.I.T. LINCOLN LABORATORY DOPPLER WEATHER RADAR PROGRAM**

J. E. EVANS (MIT, Lexington, MA) and D. H. TURNBULL (FAA, Washington, DC) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 76-79. FAA-sponsored research.

Attention is given to the development status of a Next Generation Weather Radar-like transportable weather radar support facility which is being used to validate and refine scanning strategies, data processing methods, and weather detection algorithms applicable to the FAA's Terminal Doppler Weather Radar. Among the operational issues to be resolved by these research efforts are siting, optimum scanning strategy, optimum update rate, and interfacing with ATC facilities. Emphasis will be given to the development of a microburst-detection algorithm. O.C.

**A86-37462**

**THE CENTER AND CENTRAL FLOW WEATHER SERVICE UNIT PROGRAM**

J. UECKER and M. TOMLINSON (NOAA, National Weather Service, Silver Spring, MD) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 80-83.

Begun at 13 Air Route Traffic Control Centers in April, 1978, the Center and Central Flow Weather Service Unit programs have expanded to 21 sites in the coterminous US and in Alaska. Attention is given to the current status of these FAA-National Weather Service collaborative programs, with a view to the efficiency with which observations, forecasts and warnings of potentially hazardous weather conditions can be delivered to pilots. Briefing, meteorological impact statement, and Center Weather Advisory products are illustrated. O.C.

**A86-37466**

**A COLD-SEASON NORTH AMERICAN CLIMATOLOGY OF STRONG VERTICAL WIND SHEAR**

M. CAI and J. R. GYAKUM (Illinois, University, Urbana) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 98, 99.
(Contract NSF ATM-83-05096; NSF ATM-83-11175)

The strong vertical wind shear (SWS) zones above the surface boundary layer were investigated during the North American cold season by utilizing the excellent vertical resolution of the significant level wind data of a rawinsonde. Six-month twice-daily mandatory-level sounding data, including geopotential height, temperature and wind information, and significant wind and temperature data, of October 1, 1983 to March 31, 1984 were examined from latitude 25-70 N and longitude 50-130 W. SWS is defined as being geostrophically equivalent to a horizontal temperature contrast of 15.5 C/500 km (Sanders, 1967). It is found that during the cold season the tropospheric SWS zones occur preferentially in middle latitudes and in the western and eastern coastal North American regions, and a distinct minimum of events is observed in the central section of the continent at all levels. R.R.

**A86-37484**

**WINDSHEAR DETECTION USING A DOPPLER ACOUSTIC SOUNDER (SODAR)**

J. M. FAGE and P. HUGUET (Remtech, S. A., Velizy-Villacoublay, France) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 192-195. refs

Use of Doppler sodar for obtaining windshear and meteorological data is discussed. The sodar mesaures wind speed and wind direction, vertical wind speed, turbulence, and thermal stratification at altitudes up to 2000 ft, with about 100 ft resolution and 1-min time step. The sodar was shown to operate efficiently at adverse conditions of heavy rain, strong wind, or high background noise, and for all meteorological situations a high degree of correlation was obtained between the sodar and the airborne wind data. By combining a vertically pointed sodar with a network of anemometers of the Low Level Windshear Alarm System (LLWAS), a three-dimensional description of the windflow around airports is achieved, detecting the windshear associated with low level jets or with temperature inversion layers. The sodar is also successfully applied in the field of air pollution control. I.S.

**A86-37485**

**EVALUATION OF THE ASR-9 WEATHER REFLECTIVITY PRODUCT**

M. E. WEBER (MIT, Lexington, MA) and J. R. ANDERSON (Illinois, University, Urbana) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 196-202. FAA-sponsored research.

The airport surveillance radar (ASR)-9 and its weather processor are described, and the utility of its weather reflectivity product in an air traffic control environment is evaluated. The radar transmits either linearly or circularly polarized signals, selected on the basis of air traffic control requirements. A simulation procedure that utilizes a pencil-beam Doppler weather radar data and ground clutter measurements is described. Examples of the simulated weather reports are presented to illustrate: (1) partial beamfilling due to the fan-shaped surveillance antenna pattern; (2) attenuation of low velocity weather by the clutter filters; and (3) the effects of the spatial filters used in weather processing. I.S.

**A86-37487**

**WIDE AREA REAL-TIME THUNDERSTORM MAPPING USING LPATS - THE LIGHTNING POSITION AND TRACKING SYSTEM**

W. A. LYONS, K. G. BAUER (R Scan Corp., Minneapolis, MN), R. B. BENT, and W. H. HIGHLANDS (Atlantic Scientific Corp., Melbourne, FL) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 207-214.

The principles of operation of a time-of-arrival Lightning Position and Tracking System (LPATS) network are described, together with the techniques employed to display and interact with the data base of LPATS networks currently in operation. LPATS provides an instantaneous, sub-synoptic view of thunderstorms on a single display, whereas some ten radars would be needed to be composited to provide the same thunderstorm tracking capability. Aside from providing nowcasting support to aviation forecasters, pilot briefers, and controllers, the use of the LPATS data has greatly reduced the number of false alarms associated with other means of thunderstorms detection. Representative case studies are presented. I.S.

**A86-37491**

### EVALUATING THE NEW AUTOMATED WEATHER OBSERVING SYSTEM

V. L. NADOLSKI and J. T. BRADLEY (NOAA, Test and Evaluation Div., Sterling, VA) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Proprints . Boston, MA, American Meteorological Society, 1985, p. 226-232. refs

A testing method for evaluating automated weather observing systems (AWOSs) is described and applied to the Lynchburg AWOS-3 evaluation. The evaluation scheme consists of: (1) an extensive software testing to ensure the correct programming of the AWOS-3 algorithms, (2) the engineering and environmental chamber testing of the total system, and (3) field tests conducted to determine responsiveness of the system and its limitations (particularly of the sensors), and adequacy of the algorithms. The test method is applicable to other types of AWOS and will be shortly used to evaluate a sophisticated NWS Automated Surface Observing System (ASOS). I.S.

**A86-37495**

### THE CLASSIFY, LOCATE, AND AVOID WIND SHEAR (CLAWS) PROJECT AT DENVER'S STAPLETON INTERNATIONAL AIRPORT - OPERATIONAL TESTING OF TERMINAL WEATHER HAZARD WARNINGS WITH AN EMPHASIS ON MICROBURST WIND SHEAR

J. MCCARTHY and J. WILSON (National Center for Atmospheric Research, Boulder, CO) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 247-256. NSF-supported research. refs
(Contract DOT-FA01-82-Y-10513)

**A86-37496*** SASC Technologies, Inc., Hampton, Va.

### NUMERICAL SIMULATION OF PRECIPITATION INDUCED DOWNBURSTS

F. H. PROCTOR (SASC Technologies, Inc., Hampton, VA) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 257-264. refs
(Contract NAS1-17409)

Using the Terminal Area Simulation System (TASS), numerical simulations of downburst structure and sensitivity, based on vertical profiles of environmental temperature, humidity and wind velocity observed during the June and August 1982 JAWS project, are presented. Two-dimensional axisymmetric simulations examining downburst evolution, structure and sensitivity, assume a 40-m constant grid size on a 10-km diameter 5-km deep cylindrical domain. The three-dimensional experiment, examining the effects of vertical wind shear and other asymmetrical aspects of the downpour, assumed a 500-m constant horizontal grid size and a 35 x 35 x 18.5-km area. In the downburst primary structure depicted, outflow speeds were found to be sensitive to environmental temperature and humidity, as well as to precipitation radius and intensity. A vortex ring was found to propagate downwards, and maximum outflow winds occur when the vortex ring first reaches the surface. R.R.

**A86-37497**

### CATEGORIZATION OF ATMOSPHERIC TURBULENCE IN TERMS OF AIRCRAFT RESPONSE FOR USE IN TURBULENCE REPORTS AND FORECASTS

E. W. TURNER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 265-268.

The USAF, in an attempt to further categorize atmospheric turbulence, has proposed a method whereby individual aircraft gust sensitivity would be taken into account. The selected approach is to utilize the gust loads formula which relates the peak accelerations to be expected on one airplane to the peak accelerations measured on another airplane for flight through the same rough air. Topics discussed in detail include: (1) the relationship between gust amplitude and aircraft size, (2) the lift curve slope, and (3) the gust alleviation factor. It is concluded that the proposed method for calculating gust sensitivity should provide sufficient accuracy for turbulence forecasting. However, the amount of time spent in turbulence and its effect on pilot fatigue must also be taken into account. K.K.

**A86-37498**

### DEVELOPMENT OF CAT DETECTION AND FORECASTING TECHNIQUES FOR THE PROFS CENTRAL WEATHER PROCESSOR

J. L. KELLER (Dayton, University, OH) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 269-276. refs

A computer-generated Specific Clear-air Turbulence Risk (SCATR) index which may be instrumental in clear-air turbulence (CAT) detection is presented. The CAT phenomenon is most frequently found near the tropopause within jet stream/internal fronts associated with active extratropical cyclones. The SCATR index is formulated on the notion that while CAT is a subgrid-scale phenomenon in terms of what an aircraft experiences during an encounter, outbreaks of CAT are attributed to larger, grid-scale dynamical processes. The results of case studies suggest that this index provides a CAT forecast that is significantly better than those provided by traditional, subjective indices. Practical SCATR index applications include both short- and medium-range forecasts of CAT; numerical values may be used in flight-path optimization programs and flight-simulation software. In addition, this index may eventually incorporate other effects, such as terrain, which are important in determining the formation and potential intensity of CAT regions more accurately. K.K.

**A86-37500**

### USE OF COMPUTER TECHNOLOGY IN THE OPERATIONS OF THE NATIONAL AVIATION WEATHER ADVISORY UNIT

M. D. MATHEWS (NOAA, National Severe Storms Forecast Center, Kansas City, MO) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 285-288. refs

The application of computer technology to aviation forecasting is discussed. The area forecasts contain information on hazards, the position and movement of synoptic features, icing, turbulence, and the clouds and weather. The four computer systems utilized by the in-flight meteorologists are (1) the Advanced Operating System, (2) the Automation of Field Operations and Services, (3) the Weather Message Switching Center, and (4) the Centralized Storms Information Systems. The development of pilot weather reports on icing, turbulence, and clouds and weather from the computer data is described. I.F.

**A86-37501*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### UPPER AIR FORECASTING FOR AVIATION IN THE UNITED STATES

R. STEINBERG (NASA, Lewis Research Center, Cleveland, OH) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 289-294. refs

It is shown that the present forecast models used in the aviation digital forecast (ADF) product for automated flight planning in the U.S. did not improve in accuracy and precision over the past two decades. A new approach to the upper air forecasting is presented in the NASA/NOAA MERIT project. In MERIT, a concept of a tailored analysis is used, based on a high density automated aircraft report database (including radiosonde and satellite data), producing an accurate and precise description of the initial state of the atmosphere, and a relatively simple forecast model to move the forecast forward in time. The steadily updated 2-12 h forecasts provided every 3 h will be more efficient and accurate than the present 18 and 24 h forecasts provided every 12 hours. I.S.

**A86-37504**

**THE AVIATION WEATHER FORECASTING TASK FORCE - ASSESSING THE CURRENT SYSTEM**

J. MCCARTHY and P. J. OROURKE (National Center for Atmospheric Research, Boulder, CO) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 310-315. NSF-sponsored research.
(Contract DOT-FA01-84-Z-02051)

The objectives of the Aviation Weather Forecasting Task Force that was developed to identify weather problems in the aviation industry are discussed. The need for the formation of automatic aircraft report data bases to include wind, temperature, and turbulence observations, and for more accurate numerical forecast and warning products is examined. Methods of improving aviation meteorological training, pilot weather reports, and private weather services are studied. I.F.

**A86-37511**

**THE IMPACT OF PRIVATE METEOROLOGY ON PRIVATE AVIATION**

J. BLOCK (Kavouras, Inc., Minneapolis, MN) IN: International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints . Boston, MA, American Meteorological Society, 1985, p. 344-346.

**A86-39566#**

**AERODYNAMIC CHARACTERISTICS OF AN OSCILLATING AIRFOIL**

R. H. WICKENS (National Aeronautical Establishment, Low Speed Aerodynamics Laboratory, Ottawa, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 34-49. refs

Results are reported from wind tunnel tests to study the effects of dynamic aerodynamics on the efficiency of a NACA 0018 airfoil used on a Darreius vertical axis wind turbine (VAWT). The topic is of interest because of uncontrolled pitching which occurs during operation and which produces stall, turbulence and separation effects that reduce efficiency. Present stream-tube theory and axial momentum models are not applicable in the unstable regimes. The wind tunnel tests were conducted with a 45 m/sec flow with an Re of 1.5 million. The situation mimicked typical wind turbine operational conditions. The airfoil was mounted on a hydraulic actuator to allow it to rotate about its quarter-chord location and to control the extent and frequency of oscillations. Data were also gathered on the performance in a steady flow for comparative purposes. Summary data are provided on the static and total pressures over a complete cycle of oscillation, and related to the angles of attack, time of onset of stall, and the lift and drag coefficients. The limitations of the study with regard to the absence of consideration of the flow acceleration experienced by an advancing blade are noted. M.S.K.

**N86-26714#** Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.

**A MICROCOMPUTER POLLUTION MODEL FOR CIVILIAN AIRPORTS AND AIR FORCE BASES**

H. M. SEGAL, J. K. KEMP, and P. L. HAMILTON Dec. 1985 55 p
(AD-A163232; FAA-EE-85-4; AFESC/ESL-TR-85-41) Avail: NTIS HC A04/MF A01 CSCL 09B

Over the past five years, the Federal Aviation Administration and the United States Air Force have developed a number of user-friendly emissions and dispersion models for air quality assessment purposes. The first, Simplex A was completed in July 1981. The second, called Emissions and Dispersion Modeling System (EDMS), has just been completed and this report constitutes its User's Guide. First, this User's Guide shows how the EDMS system evolved from the earlier, more complex AVAP and AQAM systems. Then, it identifies the hardware and software required to run the system and provides instructions on how to add, delete or change standard information. Finally, through a 125-step example problem, it instructs the user on how to input and process data to produce: (1) an emissions inventory of all sources at an airport/airbase, and (2) an estimate of the concentrations of these sources at specified locations. An inexperienced user should be able to process the example problem in less than three hours. Author (GRA)

**N86-26715#** Air Force Engineering and Services Center, Tyndall AFB, Fla. Engineering and Services Lab.

**AIRCRAFT ENGINE EMISSIONS ESTIMATOR Final Report, Jan. 1983 - Sep. 1985**

G. D. SEITCHEK Nov. 1985 101 p refs
(AD-A164552; AFESC/ESL-TR-85-14) Avail: NTIS HC A06/MF A01 CSCL 21E

The objective of this effort is to revise the Aircraft Emission Estimation Techniques (ACEE) Handbook to reflect changes in the Air Force aircraft inventory that have occurred since 1975. A complete listing of current Air Force aircraft and their associated engines is included. Emission factors for most of these engines are provided, along with examples for calculating emissions from aircraft operations, and analyzing their impact. This report supersedes CEEDO-TR-78-33, Aircraft Emission Estimation Techniques (ACEE). Author (GRA)

**N86-27727*#** Air Force Geophysics Lab., Hanscom AFB, Mass.

**PROFILES OF TEMPERATURE AND DENSITY BASED ON EXTREMES AT 5, 10, 20, 30 AND 40 KM**

A. J. KANTOR, P. TATTELMANN, and F. A. MARCOS *In* International Council of Scientific Unions Handbook for MAP, Vol. 18 4 p Dec. 1985
Avail: NTIS HC A23/MF A01; also available from SCOSTEP Secretariat, Illinois Univ., 1406 West Green Street, Urbana, Ill. 61801 CSCL 04A

Information on the vertical distribution of expected extremes of temperature and density are required for the design and operation of systems traversing the atmosphere. Such data are particularly important at altitudes from the surface to approximately 80 km for developing all types of airborne vehicles ranging from helicopters and airplanes to sophisticated aerospace systems. Vertical profiles of temperature and density have been developed based on 1- and 10-percent hot and cold temperatures and 1- and 10- percent high and low densities occurring during the most severe month at the worst locations for which reliable upper-air data are available. The model profiles, from the surface to 80 km, are based on extremes that occur at 5, 10, 20, 30, and 40 km. There are 20 profiles for extreme temperatures (5 levels by 4 percentiles) that include associated densities, and 20 analogous profiles for extreme densities including associated temperatures. Consequently, a set of realistic profiles (rather than envelopes) of temperature and density, associated with extremes at each of 5 specified levels in the troposphere and stratosphere, are now available for altitudes up to 80 km. Author

**N86-27835*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AIRBORNE LIDAR MEASUREMENTS OF EL CHICHON STRATOSHPERIC AEROSOLS**

M. P. MCCORMICK and M. T. OSBORN (SASC Technologies, Inc., Hampton, Va.) Jul. 1982 49 p Supersedes NASA-RP-1136 NASA-RP-1148
(NASA-RP-1166; L-16107; NAS 1.61:1166) Avail: NTIS HC A03/MF A01 CSCL 04A

A NASA Electra airplane outfitted with a lidar system was flown in July 1982 between the latitudes of 42 deg. N and 12 deg. N. The primary purpose of this mission was to determine the spatial distribution and aerosol characteristics of the El Chichon-produced stratospheric material. This report presents the lidar data from that flight mission. Representative profiles of lidar backscatter ratio, plots of the integrated backscattering function versus latitude, and contours of backscatter mixing ratio versus altitude and latitude are given. In addition, tables containing numerical values of the backscatter ratio and backscattering functions versus altitude are supplied for each profile. The largest amount of material produced by the El Chichon eruptions of late March-early April 1982 which was measured by this flight resided south of 30 deg. N and was concentrated above 21 km in a layer that peaked at 24 to 27 km. In this latitude region, peak backscatter ratios at a wavelength of 0.6943 microns were approximately 50, and peak optical depths were calculated to be 0.2. This report presents the results of this mission in a ready-to-use format for atmospheric and climatic studies. Author

**N86-27851#** Radio Technical Commission for Aeronautics, Washington, D. C.
**MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE THUNDERSTORM DETECTION EQUIPMENT**
May 1986 75 p
(RTCA/DO-191) Avail: NTIS HC A04/MF A01

Minimum operational performance standards for non-radar airborne thunderstorm detection equipment are explained in this document. These standards specify system characteristics that should be useful to designers, manufacturers, installers and users of the equipment. Information needed to understand the rationale for equipment characteristics and requirements is given. Typical equipment applications and operational goals as envisioned by Special Committee 154 are discussed. The minimum performance standards for the equipment are given. These standards specify the required performance under standard and environmental conditions. Also included are recommended bench test procedures necessary to demonstrate equipment compliance with the stated minimum requirements. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing. The operational performance characteristics for equipment installations are described and conditions that will assure the equipment is used properly in the expected operational environment are defined. B.W.

**N86-27855*#** LuTech, Inc., Hayward, Calif.
**ANALYSIS OF DIRECT AND NEARBY LIGHTNING STRIKE DATA FOR AIRCRAFT Final Report**
D. V. GIRI, R. S. NOSS, D. B. PHUOC, and F. M. TESCHE Jun. 1983 205 p
(Contract NAS1-16893)
(NASA-CR-172127; NAS 1.26:172127) Avail: NTIS HC A10/MF A01 CSCL 04B

A method for interpreting direct strike and nearby strike lightning data on aircraft is discussed. The theoretical basis for the interpretation involves a transmission line model for the aircraft, and is discussed. Results of applying this model to the F-106 aircraft are presented and in the natural resonances are computed for several different electrical representations of the aircraft. The signal processing techniques useful for extracting pole (resonance) information from experimental data are discussed, and the use of these techniques on the measured lightning data is illustrated. Finally, the results of a related ground-based lightning experiment are discussed and data are presented. The purpose of this test was to gain additional understanding of the resonance properties of the F-106 aircraft. Author

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# MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-37177**
**TECHNIQUES FOR OPTIMIZING COMPUTER PERFORMANCE IN REAL-TIME FLIGHT SIMULATION**
R. M. HOWE (Michigan, University, Ann Arbor) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 1-12.

The dynamic performance of real-time flight simulators is often limited by inherent delays in both input and output interfaces with the computer. For example, an output interface consisting of D to A converters using zero-order extrapolation introduces the equivalent of a half-frame delay. In this paper it is shown how, by operating the simulation at a computer frame rate that is less than the maximum possible frame rate, the effect of the D to A lag and other interface delays can be completely eliminated. Additional improvements in performance can be realized by A to D sampling of continuous inputs to the simulation at a frame rate which is a multiple of the overall integration frame rate used in the digital simulation. Frequency-domain techniques are used for quantitative analysis of the dynamic accuracy of each of these interface-compensation methods. The results are compared with the dynamic performance when no compensation is used, or when more traditional compensation methods are employed. Author

**A86-37180**
**SIMULATION SUPPORT SOFTWARE IN A REAL-TIME ENVIRONMENT AT THE U.S. AIR FORCE FLIGHT TEST CENTER**
R. A. WOOD (USAF, Flight Test Center, Edwards AFB, CA) and S. E. LOUTON (Singer Co., Link Flight Simulation Div., Edwards AFB, CA) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 41-52.

Attention is given to the character and performance of the extensive support software used by the U.S. Air Force's Flight Test Center, which has been used to educate test personnel, determine flight test envelopes, develop modifications to flight control systems, and investigate accidents. The software employed eases and systematizes both the development and operation of aircraft flight simulations. The aircraft models run under the control of the support software, which provides the interface to the user, cockpit, and remaining computer hardware. O.C.

**A86-37194*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**CGI DELAY COMPENSATION**
R. E. MCFARLAND (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 231-262. refs

Computer-generated graphics in real-time helicopter simulation produces objectionable scene-presentation time delays. In the flight simulation laboratory at Ames Research Center, it has been determined that these delays have an adverse influence on pilot performance during agressive tasks such as nap of the earth (NOE) maneuvers. Using contemporary equipment, computer generated image (CGI) time delays are an unavoidable consequence of the operations required for scene generation. However, providing that magnitude distortions at higher frequencies are tolerable, delay compensation is possible over a restricted frequency range. This range, assumed to have an upper limit of perhaps 10 or 15 rad/sec, conforms approximately to the bandwidth associated with helicopter handling qualities research. A compensation algorithm is introduced here and evaluated in terms of tradeoffs in frequency responses. The algorithm has a discrete basis and accommodates both a large, constant transport delay interval and a periodic delay interval, as associated with asynchronous operations. Author

**A86-37395**

**DECOUPLING OF NONLINEAR SYSTEMS, NONCOMMUTATIVE GENERATRIX SERIES, AND LIE ALGEBRAS [DECOUPLAGE DES SYSTEMES NON LINEAIRES, SERIES GENERATRICES NON COMMUTATIVES ET ALGEBRES DE LIE]**

D. CLAUDE (CNRS, Laboratoire des Signaux et Systemes, Gif-sur-Yvette, France) SIAM Journal on Control and Optimization (ISSN 0363-0129), vol. 24, May 1986, p. 562-578. In French. refs

The joint use of noncommutative generating power series and Lie algebras gives an algebraic approach for decoupling problem of nonlinear systems. A coherent decoupling method is produced using the additional notion of the immersion of a system into another, a concept which makes clear the fact that two systems have the same input-output behavior. Thus, a judicious choice of feedback which gives decoupling is able to immerse a system into a system defined on R super eta, with eta depending on the characteristic numbers of the system. Author

**A86-38376**

**TECHNIQUES FOR SORTIE GENERATION ANALYSIS**

J. A. SHIMIZU, N. CHANG, and R. S. MORRIS (Northrop Corp., Aircraft Div., Hawthorne, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 18 p.
(SAE PAPER 851950)

The force effectiveness of tactical fighter units in meeting enemy threats is largely dependent on the aircraft capability to generate sorties. Sortie generation is a function of aircraft inherent design characteristics, operating conditions, and the quantity and availability of support resources. This paper examines a technique for analyzing the impact of these constraints and their interrelationships. The technique presented offers a practical approach for evaluating various operational and support policies by measuring their effect on the system's sortie generation capability. More importantly, the technique provides an important tool for evaluating the impact of design characteristics (particularly reliability and maintainability) on combat capability where the performance measure is, again, sortie generation capability. Author

**A86-38807#**

**ASTROS - AN ADVANCED SOFTWARE ENVIRONMENT FOR AUTOMATED DESIGN**

D. L. HERENDEEN, R. L. HOESLY (Universal Analytics, Inc., Playa del Rey, CA), E. H. JOHNSON (Northrop Corp., Hawthorne, CA), and V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 59-66. refs
(Contract F33615-83-C-3232)
(AIAA PAPER 86-0856)

The 'ASTROS' Automated Structural Optimization System combines a general purpose executive, a scientific data base management system, and a problem-oriented control language into a powerful and flexible tool for the design of engineering application software. The primary function of such software is the integration of specific functional modules from existing sources into a cohesive system for automated aerospace structure design; this encompasses, in addition to finite element methods, static and dynamic structural characteristics, aerodynamics, sensitivity analysis, optimization, and control systems. O.C.

**A86-39034#**

**MULTI-INPUT MULTI-OUTPUT AUTOMATIC DESIGN SYNTHESIS FOR PERFORMANCE AND ROBUSTNESS**

V. C. GORDON and D. J. COLLINS (U.S. Naval Postgraduate School, Monterey, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 482-489) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 281-287. Previously cited in issue 22, p. 3319, Accession no. A85-45929. refs

**N86-27018#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**AN EFFICIENT DECISION-MAKING-FREE FILTER FOR PROCESSES WITH ABRUPT CHANGES**

H. A. P. BLOM 10 Sep. 1984 10 p Presented at 7th IFAC Symposium on Identification and System Parameter Estimation, York, England, 3-7 Jul. 1985
(NLR-MP-84080-U; B8578435; ESA-86-96970) Avail: NTIS HC A02/MF A01

The system of linear stochastic difference equations with Markovian coefficients was generalized to cover processes in R sup n which jump simultaneously with the coefficients. The additional modeling potential of this generalized system is illustrated. For filtering partial observations of the generalized system, the Interacting Multiple Model (IMM) algorithm is given. It consists of a bank of N interacting Kalman-like filters which cooperate with a filter for the N state Markov process and is free of any decision making mechanism. Comparisons with other algorithms for processes with abrupt changes show that the IMM algorithm performs very well at the cost of a relatively low computational load. Due to the generalization, the IMM algorithm is a serious competitor of decision directed filters for processes in R sup n with additive jumps. ESA

**N86-27926#** Lockheed-California Co., Burbank.

**KRASH85 USER'S GUIDE: INPUT/OUTPUT FORMAT Final Report, Jan. 1984 - Sep. 1984**

M. A. GAMON, G. WITTLIN, and W. L. LABARGE Jul. 1985 235 p
(DOT/FAA/CT-85/10-REV; LR-30777-REV) Avail: NTIS HC A11/MF A01 CSCL 09B

Program KRASH as modified under Contract DTFA03-84-C-00004 is described. The updated version is denoted KRASH85. This document is a User's Guide and defines the input and output formats appropriate for KRASH85. Features that are incorporated into KRASH85 include: an improved plastic hinge moment algorithm; gear-oleo metering pin coding; load-interaction curves; an expanded initial conditions subroutine (combined with NASTRAN); a comprehensive energy balance; center of gravity (c.g.) displacement, velocity, acceleration and force time histories; revised vertical beam orientation coding; provision to save data for post-processing i.e., acceleration, mass location and forces; provisions to input preprocessed data; a corrected uncoupled KR curve unloading/reloading algorithm; provisions to define a tire spring (remains normal to ground plane); provisions to number the masses to an arbitrary sequence; and an option to compute section shear and moment distributions. Author

**N86-27929#** Toronto Univ. (Ontario). Inst. for Aerospace Studies.

**FLIGHT SIMULATION MOTION-BASE DRIVE ALGORITHMS. PART 2: SELECTING THE SYSTEM PARAMETERS**

L. D. REID and M. A. NAHON May 1986 231 p Sponsored by tyhe Canadian Transportation Development Centre
(UTIAS-307; ISSN-0082-5255) Avail: NTIS HC A11/MF A01

A project aimed at developing and testing flight simulator motion-base drive algorithms suited for commercial jet transports is discussed. Full six degrees-of-freedom motion of a synergistic motion-base is being studied. Three forms for these algorithms are being considered: (1) classical linear washout, (2) optimal control, and (3) coordinated adaptive washout. It is felt that the latter two techniques may provide some advantages over the classical, which is currently employed in most commercial flight simulators. A filter parameter selection process using typical jet transport maneuvers as input signals is discussed. The filter parameters were adjusted to produce a range of washout characteristics. The pilot's motion sensations produced by these tests were estimated through the use of linear models of the human vestibular system. Nine sets of washout filters were generated for future evaluation by a group of pilots. Computer listings of the real-time software are presented along with numerous test results. Author

**N86-27930*#** College of William and Mary, Williamsburg, Va. Dept. of Computer Science.

**A HIGH-ORDER LANGUAGE DOR A SYSTEM OF CLOSELY COUPLED PROCESSING ELEMENTS Final Report**

S. FEYOCK and W. R. COLLINS Jul. 1986 67 p
(Contract NAG3-232)
(NASA-CR-177280; NAS 1.26:177280) Avail: NTIS HC A04/MF A01 CSCL 09B

The research reported in this paper was occasioned by the requirements on part of the Real-Time Digital Simulator (RTDS) project under way at NASA Lewis Research Center. The RTDS simulation scheme employs a network of CPUs running lock-step cycles in the parallel computations of jet airplane simulations. Their need for a high order language (HOL) that would allow non-experts to write simulation applications and that could be implemented on a possibly varying network can best be fulfilled by using the programming language Ada. We describe how the simulation problems can be modeled in Ada, how to map a single, multi-processing Ada program into code for individual processors, regardless of network reconfiguration, and why some Ada language features are particulary well-suited to network simulations. Author

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## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-39057*#** Missouri Univ., Rolla.

**WAVE ENVELOPE AND FINITE ELEMENT APPROXIMATIONS FOR TURBOFAN NOISE RADIATION IN FLIGHT**

A. V. PARRETT (GM Noise and Vibration Laboratory, Milford, MI) and W. EVERSMAN (Missouri-Rolla, University, Rolla) AIAA Journal (ISSN 0001-1452), vol. 24, May 1986, p. 753-760. Previously cited in issue 01, p. 75, Accession no. A85-10877. refs
(Contract NAG1-198)

**A86-39058*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**FLIGHT EFFECTS ON NOISE FROM COAXIAL DUAL FLOW. I - UNHEATED JETS**

R. DASH (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, May 1986, p. 761-769. Previously announced in STAR as N83-17238. refs
(Contract NCC2-75)

The effects of flight on sound radiated from embedded, uncorrelated ring sources convecting along the midst of the primary and the secondary streams of a coaxial dual flow which emerges from a moving nozzle into the ambience are studied. Cold jets are examined. The problem is posed as a double vortex-sheet flow model which involves deliberate suppression of inherent instabilities of the flow and is formulated, as a linear problem, in terms of the combined contributions of two independent uncorrelated quadrupole-type ring sources, the one convecting in the primary flow representing the sources generated due to the interaction at the primary/secondary interface and the other convecting in the secondary flow representing the sources generated due to the interaction at the secondary/ambient interface. The analysis shows that the effects of flight induce: (1) amplication of noise in the forward quadrant, (2) reduction of noise in the aft quadrant and (3) absolutely no impact on radiation of noise at Theta = 90 deg to the jet axis. Author

**A86-39069#**

**FINE STRUCTURE OF SUBSONIC JET NOISE**

W. G. RICHARZ (Carleton University, Ottawa, Canada) AIAA Journal (ISSN 0001-1452), vol. 24, May 1986, p. 849, 850. NSERC-supported research.

An examination is conducted of the fine structure of the sound pressure spectrum of a subsonic jet, in order to correlate the fine structure with the sound from large scale structures in the jet flow. It is noted that the phenomenon of diffraction appears to be responsible for the observed fine structure. Attention is given to the influence of the analysis technique on the appearance of far field pressure spectra. O.C.

**N86-26804#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

**FLIR, NVG AND HMS/D SYSTEMS FOR HELICOPTER OPERATION: REVIEW**

H. D. V. BOEHM *In* AGARD Visual Protection and Enhancement 27 p Dec. 1985 refs
Avail: NTIS HC A11/MF A01

In the last decade, electro-optical systems have been used successfully in military and civil applications. They extend the scope of operation of ground vehicles, helicopters and fixed wing aircraft from daytime into nighttime, with a 24 hour readiness covering even bad weather conditions. The visual aids fall into two physical categories: the image intensifiers, which amplify reflected residual light in the near infrared and the thermal imager, which detect the thermal radiation of all bodies mainly in the 8 to 12 micrometer atmospheric window for bodies with T approx. 20 C. During the last five years, the investigator has carried out helicopter flight trials at night using examples of all these visionic aids (FLIR, LLLTV, NVG, HMS/D and Direct View Optics) for piloting and observation tasks. The detection, recognition and identification range of nine different FLIR were tested in ground and laboratory tests. The evaluation of an optical sensor platform location in the helicopter nose-, roof- and mast-mounted versions, the comparison of thermal and intensifier images and the NVG compatible cockpit were topics of the tests. The optical sensors are described with their limitations and some results of the trials are given, with regard to the pilot's stress situation and eye safety. Author

**N86-26811#** Marconi Avionics Ltd., Rochester (England). Airborne Display Div.

**NIGHT VISION BY NVG WITH FLIR**

G. C. BULL *In* AGARD Visual Protection and Enhancement 7 p Dec. 1985
Avail: NTIS HC A11/MF A01

Night Vision Goggles and fixed forward looking infrared equipment both have particular operational shortcomings when used in a fixed wing aircraft for close air support at night. However, when operated together, they compensate for each others deficiencies forming a highly capable system at far less cost and complexity compared with other night vision systems. Author

**N86-27473#** Columbia Univ., New York. Dept. of Civil Engineering.

**NOISE TRANSMISSION INTO PROPELLER AIRCRAFT Monthly Report**

R. VAICAITIS *In* Shock and Vibration Information Center(Defense), The Shock and Vibration Digest, Volume 17, No. 8 , p 15-20 Aug. 1985
Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

Papers and reports, most of which were written since 1981, that are concerned with airborne and structure-borne noise transmission into a propeller-driven aircraft are surveyed. Special attention is given to a new propfan aircraft. Author

**N86-27969#** Federal Aviation Administration, Washington, D.C.
**ADVISORY CIRCULAR: ESTIMATED AIRPLANE NOISE LEVELS IN A-WEIGHTED DECIBELS**
27 Mar. 1986 38 p
(AC-36-3D) Avail: NTIS HC A03/MF A01

Federal Aviation Regulation (FAR) Part 36 requires the reporting of turbojet and large transport category aircraft certificated noise levels in units of Effective Perceived Noise Level in decibels. Many airport and other community noise analyses utilize a noise rating scale that is based upon A-weighted decibels. For this reason, A-weighted noise levels for aircraft under FAR Part 36 conditions were estimated to provide a reference source for aircraft noise levels that is consistent with the many noise rating scales having A-weighted noise level as the basic measurement. Listings of estimated aircraft noise levels in units of A-weighted sound level in decibels, ranked in descending order are presented. This information is provided both for aircraft that were noise type certificated under FAR Part 36 and for aircraft for which no such requirement currently exists. Author

**N86-27970*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**SPECTRA OF NOISE AND AMPLIFIED TURBULENCE EMANATING FROM SHOCK-TURBULENCE INTERACTION: TWO SCENARIOS**
H. S. RIBNER Mar. 1986 40 p Sponsored by the Natural Sciences and Engineering Research Council of Canada Prepared in cooperation with Toronto Univ. (Ontario)
(NASA-TM-88766; NAS 1.15:88766; UTIAS-TN-260; ISSN-0082-5263) Avail: NTIS HC A03/MF A01 CSCL 20A

This work is a small extension of NACA studies of the early fifties that predicted amplification of turbulence on passing through a shock wave (observed for turbulent boundary layers), as well as the generation of intense noise (observed for supersonic jets). The first solved the basic gasdynamics problem of the interaction of an infinite planar shock with a single three-dimensional spectrum component of turbulence (an oblique sinusoidal shear wave). The second developed the comprehensive 3D spectrum analysis necessary to generalize the scenario to the interaction of a shock wave with convected homogeneous turbulence. Numerical calculations were carried out to yield curves (vs. Mach number) of rms sound pressure, temperature fluctuation, and two components of turbulent velocity downstream of the shock, for two cases of preshock turbulence. The present numerical study reproduces these for one case and provides in addition their one-dimensional power spectra (vs. wavenumber or frequency). Ratios of the several postshock spectra to the longitudinal preshock turbulence spectrum (1D) have been computed for a wide range of Mach numbers; curves vs. wavenumber are presented for two scenarios of preshock turbulence: isotropy and axisymmetry, both based on the von Karman 3D spectrum. Author

**N86-27972#** Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.
**ANALYSIS OF HELICOPTER NOISE DATA USING INTERNATIONAL HELICOPTER NOISE CERTIFICATION PROCEDURES**
J. S. NEWMAN, E. J. RICKLEY, D. A. LEVANDUSKI, and S. B. WOOLRIDGE Mar. 1986 282 p Prepared in cooperation with Operations Research, Inc., Rockville, Md.
(PB86-186533; FAA-EE-86-01) Avail: NTIS HC A13/MF A01 CSCL 20A

The results of a Federal Aviation Administration (FAA) noise measurement flight test program involving seven helicopters are documented. Noise levels were established using the basic testing, reduction and analysis techniques specified by the International Civil Aviation Organization (ICAO) for helicopter noise certification, supplemented with some procedural refinements contained in ICAO Working Group II recommendations for incorporation into the standard. GRA

## 17

## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-38308**
**DEVELOPMENTS IN AIRWORTHINESS CONTROL FOR CANADIAN AIRLINES**
J. F. HAINES (Air Canada, Montreal) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 6 p.
(SAE PAPER 851784)

Changes in the control of aeronautics in Canada are discussed. The objectives and capabilities of the continuous maintenance system and the design approval representative system are described. The development of and requirements for the maintenance development program, which contains quality and engineering organizations, and an approved airworthiness engineering organization are examined. I.F.

**A86-38317**
**AIRCRAFT GROUND SUPPORT EQUIPMENT STANDARDIZATION - THE PROS AND CONS OF 'FUNCTIONAL' VS 'TECHNICAL' STANDARDIZATION**
J. J. MACHON (Air France, Paris) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 14-17, 1985. 14 p.
(SAE PAPER 851794)

The main international bodies currently active in the fields of aircraft Ground Support Equipment (GSE) standardization are discussed, and an attempt is made to define what standardization should or should not be in this field. The activities of the ISO, SAE, and IATA are described, and their interlinks are shown. The classes of 'technical' standardization, which concerns design type specifications and purchasing type specifications, are addressed. The meaning of 'functional' specification, and how in practice it leads to a fairly effective worldwide GSE standardization, is considered. The way in which the market may respond to technical and functional standardization is discussed. C.D.

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## GENERAL

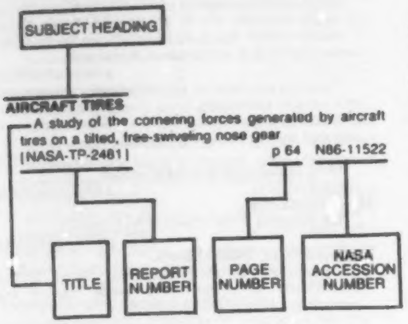
**A86-39984**
**INVESTIGATIONS IN THE HISTORY AND THEORY OF THE DEVELOPMENT OF AVIATION AND SPACE SCIENCE AND TECHNOLOGY. NUMBER 4 [ISSLEDOVANIIA PO ISTORII I TEORII RAZVITIIA AVIATSIONNOI I RAKETNO-KOSMICHESKOI NAUKI I TEKHNIKI. NUMBER 4]**
B. V. RAUSHENBAKH, ED. Moscow, Izdatel'stvo Nauka, 1985, 256 p. In Russian. No individual items are abstracted in this volume.

Papers on three main topics are presented. The first topic is a review of the history of the first 25 years of Soviet space flight. The second topic is a consideration of the history and development of aviation science and technology, with particular emphasis on aircraft design. The third topic is the Soviet manned space flight program during 1961-1981, with particular emphasis on the development of solid rocket engines. B.J.

**AERONAUTICAL ENGINEERING** / *A Continuing Bibliography (Supplement 205)*

October 1986

### Typical Subject Index Listing



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## A

**A-7 AIRCRAFT**
DIGITAC multimode control laws --- for military aircraft missions
[SAE PAPER 851826] p 594 A86-38332

**ABSTRACTS**
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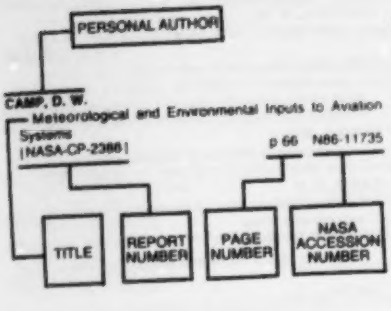

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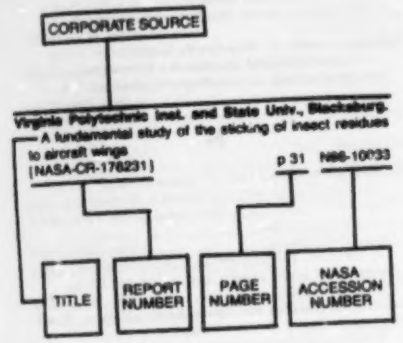
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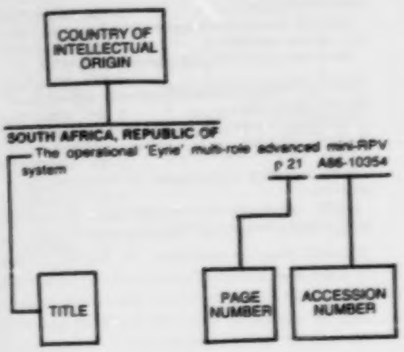
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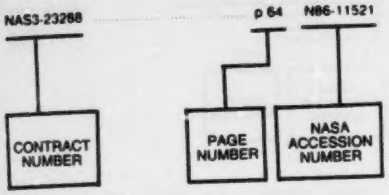

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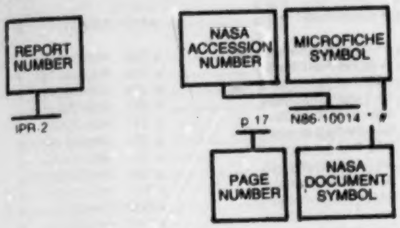

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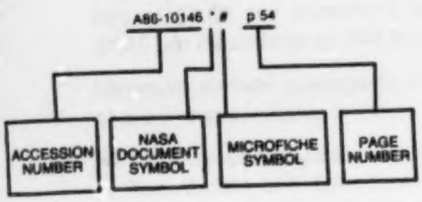

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NASA SP-7037(206)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

## (Supplement 206)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in October 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 422 reports, journal articles and other documents originally announced in October 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

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Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

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Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**Category 17 Social Sciences** 684

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**Category 18 Space Sciences** N.A.

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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# TYPICAL REPORT CITATION AND ABSTRACT

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ACCESSION NUMBER → **N86-10033*#** Virginia Polytechnic Inst. and State Univ., ← CORPORATE SOURCE
Blacksburg. Dept. of Chemistry.
TITLE → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
AUTHORS → N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs ← PUBLICATION DATE
AVAILABILITY SOURCE
CONTRACT NUMBER → (Contract NAG1-300)
REPORT NUMBERS → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF ← PRICE CODE
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The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.
Author

# TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

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ACCESSION NUMBER → **A86-11041*#** National Aeronautics and Space Administration.
Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS** ← TITLE
AUTHOR → D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) ← AUTHOR'S AFFILIATION
CONFERENCE TITLE → AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)
CONFERENCE DATE

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.
Author

# AERONAUTICAL ENGINEERING

## A Continuing Bibliography (Suppl. 206)

NOVEMBER 1986

## 01

## AERONAUTICS (GENERAL)

**A86-40232**

**HEALTH AND USAGE MONITORING TECHNIQUES FOR GREATER SAFETY IN HELICOPTER OPERATIONS**

D. G. ASTRIDGE International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 205-211. refs

Significant advancements have recently been made in helicopter gearbox monitoring technology, notably in quantitative debris monitoring (QDM) and enhanced vibration signal averaging. Attention is given to a QDM system that has demonstrated its effectiveness against a wide range of wear modes, and to vibration analysis techniques that have detected cracks and fracture modes not yet detectable by visual inspection. A comprehensive onboard monitoring system has been developed which incorporates, in addition to the two techniques mentioned, engine and rotor system monitoring elements. O.C.

**A86-40478**

**SIMULATOR UPGRADE - REGULATIONS AND BENEFITS**

E. M. BOOTHE (FAA, Atlanta, GA) IN: Simulators; Proceedings of the Conference, Norfolk, VA, March 3-8, 1985 . La Jolla, CA, Society for Computer Simulation, 1985, p. 6-12. refs

In June of 1980, the Federal Aviation Administration (FAA) Advanced Simulation Plan came into being. Since that time, there has been a significant increase in the use of Advanced Simulators in lieu of the aircraft for training and checking of pilots. It is pointed out that new advanced simulators are now coming into operation, allowing nearly 100 percent of the pilot's training and checking to be accomplished in the simulator. Attention is given to the Advanced Simulator Plan with its three phases, the National Simulation Evaluation Program, progress which has been made, regional air carriers and general aviation, and an investigation of alternatives. G.R.

**A86-40499**

**EXPERIENCES IN UK AND FRANCE IN AEROSPACE APPLICATION**

B. J. HAYES (Ciba-Geigy Plastics and Additives Co., Duxford, England) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 229-240.

A development history is presented for British and French involvement in the design and production of high performance glass and carbon fiber-reinforced composite structures for aircraft, spacecraft, and helicopters. Propulsion-related applications of such composites have encompassed not only the familiar helicopter rotor blades and driveshaft torque-tubes, but commercial aircraft propeller blades and even CFRP fan blades (which failed due to poor impact performance). Future avenues of development in this field are projected. O.C.

**A86-41037#**

**WHICH TRANSPORT TECHNOLOGIES WILL FLY?**

J. M. SWIHART (Boeing Co., Seattle, WA) Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 56-58.

The cost of ownership of commercial aircraft is seen as a factor that will limit which new technologies will be adopted. Today, for a 10 percent fuel saving, an airline can bear a premium of only 2.5 percent. Thus, some technologies that look promising technically will not pay off big enough to fly. Technologies that can be expected to pay off include: using computers to design improved wings; lighter materials such as aluminum-lithium alloys and composites (if labor and material costs for composite structures are not too great); computer-aided design/computer-aided manufacturing; microprocessor technology; fiber optics (to potentially reduce the heavy electromagnetic shielding required for electronics); and improved engines such as the counterrotating pusher turboprop. Fly-by-wire and fly-by-light systems, which might replace mechanical cable controlled flight systems, need to be studied further. Various of these technologies in combination may within a decade make possible a transport delivering over 150 seat-miles per gallon. Such an airliner would make most of today's aircraft obsolete - if the cost of ownership can be kept down. D.H.

**A86-41276**

**BRINGING ON THE B-1B**

J. P. COYNE Air Force Magazine (ISSN 0730-6784), vol. 69, June 1986, p. 63-69.

An account is given of the first year of B-1B bomber training operations at Dyess Air Force Base, Texas. The training schedule calls for the qualification of 250 pilots for four SAC B-1B operational wings by 1990, complemented by 300 copilots and 500 systems officers. Because the B-1B is so heavily dependent on computers and electronics, intensive avionics training is included in the Dyess program. Attention is given to such automated maintenance systems as the Central Integrated Test System and the Automated Tech Order System. O.C.

**A86-41800**

**DELIVERY OF B-1B CHANGES MAINTENANCE PROCEDURES**

Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 2, 1986, p. 60-62.

An evaluation is made of the consequences for maintenance procedures of the B-1B bomber's incorporation of a number of revolutionary monitoring and diagnostics systems. These encompass (1) a Central Integrated Test System dedicated to maintenance diagnostics; (2) the Core Automated Maintenance System, which will substitute electronic mail for the paperwork conventionally used in maintenance; and (3) the Consolidated Aircraft Support System, which allows an aircraft to be serviced on the ramp without need for additional ground equipment to supply air cooling, water, electricity, jet fuel, and communication lines. O.C.

**A86-43332#**
**EXPERT SYSTEMS FOR AVIATION MAINTENANCE**
R. J. HUNTHAUSEN (U.S. Army, Aviation Applied Technology, Directorate, Fort Eustis, VA) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 33 p.
(AIAA PAPER 86-1143)

Expert (AI-based) systems for military aircraft maintenance must furnish major advantages over all current manual and automatic diagnostics approaches, including the reduction of fault isolation downtimes, false removals, specialization requirements, and training requirments. Attention is given to a U.S. Army technology evaluation program aimed at the application of AI diagnostics to AH-64A, CH-47D, and AH-1S helicopters. Expert system architectures, maintenance and diagnostic information systems, expertise transfer systems, and future AI diagnostics trends are discussed. O.C.

**N86-28049*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**A TIME-BASED CONCEPT FOR TERMINAL-AREA TRAFFIC MANAGEMENT**
.I. ERZBERGER and L. TOBIAS Apr. 1986 17 p Presented at the 42nd AGARD Guidance and Control Panel Symposium, Brussels, Belgium, 6-9 May, 1985
(NASA-TM-88243; NAS 1.15:88243) Avail: NTIS HC A02/MF A01 CSCL 01B

An automated air-traffic-management concept that has the potential for significantly increasing the efficiency of traffic flows in high-density terminal areas is discussed. The concept's implementation depends on the techniques for controlling the landing time of all aircraft entering the terminal area, both those that are equipped with on-board four dimensional guidance systems as well as those aircraft types that are conventionally equipped. The two major ground-based elements of the system are a scheduler which assigns conflict-free landing times and a profile descent advisor. Landing times provided by the scheduler are uplinked to equipped aircraft and translated into the appropriate four dimensional trajectory by the on-board flight-management system. The controller issues descent advisories to unequipped aircraft to help them achieve the assigned landing times. Air traffic control simulations have established that the concept provides an efficient method for controlling various mixes of four dimensional-equipped and unequipped, as well as low-and high-performance, aircraft. Author

**N86-28050*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**GEOMETRY DEFINITION AND GRID GENERATION FOR A COMPLETE FIGHTER AIRCRAFT**
T. A. EDWARDS Apr. 1986 15 p Presented at the AGARD Symposium on Applications of CED in Aeronautics, Aix en Provence, France, 7-10 Apr. 1986
(NASA-TM-88242; A-86208; NAS 1.15:88242) Avail: NTIS HC A02/MF A01 CSCL 01B

Recent advances in computing power and numerical solution procedures have enabled computational fluid dynamicists to attempt increasingly difficult problems. In particular, efforts are focusing on computations of complex three-dimensional flow fields about realistic aerodynamic bodies. To perform such computations, a very accurate and detailed description of the surface geometry must be provided, and a three-dimensional grid must be generated in the space around the body. The geometry must be supplied in a format compatible with the grid generation requirements, and must be verified to be free of inconsistencies. This paper presents a procedure for performing the geometry definition of a fighter aircraft that makes use of a commercial computer-aided design/computer-aided manufacturing system. Furthermore, visual representations of the geometry are generated using a computer graphics system for verification of the body definition. Finally, the three-dimensional grids for fighter-like aircraft are generated by means of an efficient new parabolic grid generation method. This method exhibits good control of grid quality. Author

**N86-28051*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**DEVELOPMENT AND VALIDATION OF THE CREW-STATION SYSTEM-INTEGRATION RESEARCH FACILITY**
B. NEDELL, G. HARDY, T. LICHTENSTEIN, G. LEONG, and D. THOMPSON May 1986 24 p
(NASA-TM-86841; A-85410; NAS 1.15:86841) Avail: NTIS HC A02/MF A01 CSCL 01B

The various issues associated with the use of integrated flight management systems in aircraft were discussed. To address these issues a fixed base integrated flight research (IFR) simulation of a helicopter was developed to support experiments that contribute to the understanding of design criteria for rotorcraft cockpits incorporating advanced integrated flight management systems. A validation experiment was conducted that demonstrates the main features of the facility and the capability to conduct crew/system integration research. Author

**N86-28906#** Perkin-Elmer Corp., Pomona, Calif. Applied Science Div.
**DEVELOPMENT OF A PORTABLE WEAR METAL ANALYZER FOR FIELD USE Final Report, Aug. 1982 - Aug. 1985**
W. NIU Aug. 1985 115 p
(Contract F33615-81-C-2080)
(AD-A166013; AFWAL-TR-85-2043) Avail: NTIS HC A06/MF A01 CSCL 07D

The portable wear metal analyzer (PWMA) was developed to perform engine oil analysis when aircraft are deployed away from their home bases. The analyzer can detect nine wear metals in the parts per million concentration ranges. The analyzer uses the graphite furnace atomic absorption technology with a specially developed multi-element analysis scheme. The overall system is packaged into two militarized suitcases, including a nine-channel spectrometer, an air or water-cooled graphite furnace, a miniaturized graphite furnace power supply, a unique sample introduction device, a pneumatic supply system, and microprocessor controlled electronics. The analyzer is simple to set up and use. The operator only needs to introduce an undiluted oil sample, push a start button and wait for the results to be printed out. A brassboard system was first developed followed by six prototypes. Analytical performance as well as environmental compatibility were thoroughly evaluated on the first prototype. Consequently, design improvements were made and incorporated into five subsequent prototypes. Test results of the prototypes indicated that the instruments can meet the oil analysis need in both laboratory and rugged environments. Field tests are under way and the results will further verify the validity of the instruments. GRA

**N86-28907#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
**ACTIVITIES REPORT IN AEROSPACE RESEARCH Annual Report, 1984**
24 Apr. 1985 195 p
(ESA-86-97190) Avail: NTIS HC A09/MF A01

Research in aerodynamics; test facilities; spacecraft and aircraft construction materials; spacecraft and aircraft structures; computer science; fluid mechanics; energetics; physics; and aerospace systems is summarized. ESA

**N86-28908#** Joint Publications Research Service, Arlington, Va.
**USSR REPORT: TRANSPORTATION**
1 May 1986 61 p Transl. into ENGLISH from various Russian articles
(JPRS-UTR-86-007) Avail: NTIS HC A04/MF A01

General articles from various periodicals are reprinted on transportation in the USSR. Transportation areas are divided generally into civil aviation, motor vehicles and highways, marine and river fleets, and experimental systems. The majority of the articles are on civil aviation.

**N86-28909#** Joint Publications Research Service, Arlington, Va.
**AEROFLOT OFFICIALS ROUNDTABLE ON SECTION'S TECHNICAL PROGRESS**
S. SOKOLOV and I. KAZANSKIY *In its* USSR Report: Transportation (JPRS-UTR-86-007) p 1-9 1 May 1986 Transl. into ENGLISH from Grazhdanskaya Aviatsiya (Moscow, USSR), no. 2, Feb. 1986 p 30-33
Avail: NTIS HC A04/MF A01

A roundtable discussion is presented on the resolution of the key task of the 12th five-year plan which is the utmost acceleration of scientific and technical progress and an increase in the role of science and technology in transferring the industry onto the rails of the all around intensification and raising to the efficiency and quality of air transportation. A list and affiliation of the participant in the discussion is given. A verbatim script of the discussion is given. E.R.

**N86-28910#** Joint Publications Research Service, Arlington, Va.
**GENERAL DESIGNER BALABUYEV ON AN-124 RUSLAN FEATURES**
P. V. BALABUYEV and V. I. TOLMACHEV *In its* USSR Report: Transportation (JPRS-UTR-86-007) p 14-21 1 May 1986 Transl. into ENGLISH from Tekhnika-Molodezhi (Moscow, USSR), no. 2, Feb. 1986 p 30-35
Avail: NTIS HC A04/MF A01

An interview is presented with the designers of a new cargo aircraft. They state that the appearance of the An-22 (Antey) winged heavyweight, capable of carrying 80 tons of different cargo, became a sensation 20 years ago. Created on the same drawing board as the Antey, the Ruslan has a cargo capacity which is almost double that of its older brother 5. It has already scored 21 world records, including carrying a load of 171.2 tons to an altitude of 10,700 meters. The designers are further questioned about the basic features, advantages, weight reduction, engine type, maintenance, and flight safety. E.R.

# 02

# AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-40107#**
**AIRFOIL OPTIMIZATION**
P. KRANTZ and S. G. HEDMAN (Flygtekniska Forsoksanstalten, Bromma, Sweden) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 861-867) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 355, 356. Previously cited in issue 22, p. 3173, Accession no. A84-45023.

**A86-40108#**
**GROUND EFFECT ON SLENDER WINGS AT MODERATE AND HIGH ANGLES OF ATTACK**
J. ER-EL and D. WEIHS (Technion - Israel Institute of Technology, Haifa) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 896-904) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 357, 358. Previously cited in issue 22, p. 3174, Accession no. A84-45026.

**A86-40110*#** General Dynamics Corp., Fort Worth, Tex.
**VISCOUS EFFECTS ON TRANSONIC AIRFOIL STABILITY AND RESPONSE**
H. M. BERRY (General Dynamics Corp., Fort Worth, TX), J. T. BATINA (NASA, Langley Research Center, Hampton, VA), and T. Y. YANG (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 10-22) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 361-369. Previously cited in issue 13, p. 1845, Accession no. A85-30321. refs
(Contract NAG1-372)

**A86-40111#**
**INDICIAL COEFFICIENTS FOR A CROPPED DELTA WING IN INCOMPRESSIBLE FLOW**
V. J. E. STARK (Saab Scania AB, Linkoping, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 370-375. Research supported by the Swedish Defence Administration and Saab Scania AB. refs

Indicial coefficients and corresponding deficiency functions have been calculated for typical deflection modes of a cropped delta wing with trailing-edge flaps in incompressible flow by an approximate doublet element method for arbitrary motion. The normalized deficiency functions for the modes considered were found to be closely approximated by a single one-parameter function. The parameter, a characteristic time, was found to have the same value for this wing as for a rectangular wing of aspect ratio 3 when referred to semispan divided by freestream speed. Laplace transformation of the one-parameter function yields a generalized Theodorsen function. Author

**A86-40112#**
**EULER SOLUTIONS FOR AIRFOIL/JET/GROUND-INTERACTION FLOWFIELDS**
R. K. AGARWAL and J. E. DEESE (McDonnell Douglas Research Laboratories, St. Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 376-381. refs

Airfoil/jet/ground-interaction flowfields are calculated by solving Euler equations on body-conforming curvilinear grids. For these computations, Jameson's Euler code (FLO-53) based on an explicit Runge-Kutta time-marching finite-volume procedure is modified. Euler equations are preconditioned for computing almost incompressible flows. Euler equations capture the vortex formation behind the jet and most of the airfoil/jet/ground-plane interaction, except the effect of entrainment. Reasonable agreement is obtained between the calculated and experimental values of the lift on the airfoil for moderate values of jet-velocity to freestream-velocity ratio. Author

**A86-40115#**
**AERODYNAMIC INVESTIGATIONS TOWARD AN ADAPTIVE AIRFOIL FOR A TRANSONIC TRANSPORT AIRCRAFT**
G. REDEKER, G. WICHMANN (DFVLR, Brunswick, West Germany), and H.-C. OELKER (Braunschweig, Technische Universitaet, Brunswick, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 868-880) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 398-405. Previously cited in issue 22, p. 3173, Accession no. A84-45024. refs

**A86-40118*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**UNSTEADY TRANSONIC FLOW CALCULATIONS FOR INTERFERING LIFTING SURFACE CONFIGURATIONS**
J. T. BATINA (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 422-430. Previously cited in issue 19, p. 2742, Accession no. A85-40783. refs

**A86-40121#**

**DUAL-WING SYSTEMS WITH DECALAGE ANGLE OPTIMIZATION**

K. ROKHSAZ and B. P. SELBERG (Missouri-Rolla, University, Rolla) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 444-448. Previously cited in issue 20, p. 2850, Accession no. A84-41335. refs

**A86-41690#**

**APPLICATION OF CONTINUOUS VORTICITY PANELS TO GENERAL UNSTEADY INCOMPRESSIBLE TWO-DIMENSIONAL LIFTING FLOWS**

M. J. KIM and D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 464-471. Previously cited in issue 07, p. 842, Accession no. A85-19633. refs

**A86-41693*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**WAKE HAZARD ALLEVIATION ASSOCIATED WITH ROLL OSCILLATIONS OF WAKE-GENERATING AIRCRAFT**

V. J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 484-491. Previously cited in issue 21, p. 3039, Accession no. A85-43835. refs

**A86-41697*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**APPLICATION OF A SUPERSONIC EULER CODE (SWINT) TO WING-BODY-TAIL GEOMETRIES**

J. M. ALLEN and J. C. TOWNSEND (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 513-519. Previously cited in issue 21, p. 3040, Accession no. A85-43859. refs

**A86-41734*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**MEASURED AND PREDICTED HEATING DISTRIBUTIONS FOR BICONICS AT MACH 10**

C. G. MILLER, P. A. GNOFFO, and S. E. WILDER (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 251-258. refs

Laminar heating distributions have been measured on a 1.9 percent scale model of a generic aeroassisted vehicle taking the shape of a spherically blunted, 13-deg/7-deg biconic whose forecone section is bent upward (by 7 deg) to furnish self-trim capability at a 20-deg angle-of-attack. The results thus obtained were compared with data gathered for a straight biconic. While no Reynolds number effect on heating was noted on the windward side of the forecone, the opposite was true of the leeward side, where a Reynolds number increase caused circumferential flow separation at lower angles of attack. Generally, windward heating was predicted to within 10 percent with a computer code solving the steady, three-dimensional parabolized Navier-Stokes equations. O.C.

**A86-42168**

**EXPERIMENTAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER AT HIGH REYNOLDS NUMBERS AND A MACH NUMBER OF 0.8**

L. GAUDET (Royal Aircraft Establishment, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, March 1986, p. 83-94. refs

Measurements of the turbulent boundary layer on a sidewall of the RAE 8 ft x 8 ft wind tunnel are described. Velocity profiles and wall shear-stress measurements were obtained for a Mach number of 0.8 over a Reynolds number range of over a decade up to a value of nearly 400 million. A skin-friction relationship is deduced together with a description of the velocity profile and boundary-layer growth based upon the velocity-defect law using kinematic parameters for constant-pressure flows without heat transfer. Previous data for Mach numbers up to 2.8 obtained in the same tunnel are shown to be well matched with the present analysis and the use of simple scaling factors for compressible flows is confirmed. Author

**A86-42548**

**NUMERICAL STUDY OF THE TRAILING EDGE REGION IN SLIP FLOW REGIME**

L. GOTTESDIENER (Paris VI, Universite, Meudon, France) IN: Rarefied gas dynamics. Volume 1 . New York, Plenum Press, 1985, p. 523-533. refs

The supersonic rarefied flow over a finite flat plate has been computed using a finite-difference solution of the complete unsteady Navier-Stokes equations. The solution is advanced in time from the initial conditions until the steady state solution is reached. The computational region extends from the free stream ahead of the plate to the near wake. Both wall slip and temperature jump are included in the calculations. The results compare favorably with experimental data, but some deviations are noted in the trailing edge region. Particularly the local shear stress coefficient increases approaching the trailing edge. This result gives reinforcement of the Triple Deck Theory. Author

**A86-42605#**

**COMPUTATION OF TWO-DIMENSIONAL TRANSONIC CASCADE FLOW USING A NEW NAVIER-STOKES SOLVER**

N. SATOFUKA, K. MORINISHI (Kyoto Institute of Technology, Japan), T. TAMAKI, and A. SHIMIZU (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(AIAA PAPER 86-1381)

A new explicit method for calculating viscous flows in turbomachinery cascades has been developed. The thin-layer Navier-Stokes equations are solved by using the rational Runge-Kutta time stepping procedure of Wambecq (1978) combined with the usual central finite difference approximations. The Baldwin-Lomax (1978) eddy-viscosity model is used for turbulent flows. Convergence to a steady state is accelerated by use of the local time stepping and the residual averaging techniques. Details of the numerical method are presented along with computed result for two transonic cascades. Results are compared with experimental data to demonstrate the accuracy and computational efficiency of the present method. Author

**A86-42635*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STUDY OF HYPERSONIC INLET FLOW FIELDS WITH A THREE-DIMENSIONAL NAVIER-STOKES CODE**

A. KUMAR and G. Y. ANDERSON (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(AIAA PAPER 86-1426)

A three-dimensional Navier-Stokes code is used to study the flow through an inlet with a rectangular capture area, but with circular or essentially circular internal cross-sections. The inlet may have a center body extending partially or fully over the length of the inlet. Calculations are made under a variety of geometrical constraints imposed on the inlet cross-sections to study the flow quality in the inlet. It is observed that for this class of inlets, the boundary layer has a tendency to thicken and separate readily due to the adverse pressure gradient caused by the continuous compression in the inlet. Since no experimental results are yet available, this paper has presented only the numerical results from the present analysis. Author

**A86-42653#**

### WAKE INDUCED UNSTEADY AERODYNAMIC INTERACTIONS IN A MULTI-STAGE COMPRESSOR

V. R. CAPACE and S. FLEETER (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. USAF-supported research. refs

(AIAA PAPER 86-1455)

The effects of steady loading and the detailed aerodynamic forcing function on airfoil row unsteady aerodynamics are investigated and quantified at high reduced frequency values. For the first time, both parallel and normal gust components of the forcing function are considered. This is accomplished by a series of experiments which quantify the unsteady aerodynamics of the first stage vane row of a research compressor. The effects of steady vane aerodynamic loading with both non-constant and constant aerodynamic forcing functions are quantified. These data show that the steady loading affects only the magnitude of the complex dynamic pressure coefficient whereas the ratios of the maximum amplitudes of the parallel and normal components of the aerodynamic forcing function affects both the magnitude and the phase lag. The relative effects of the two components of the time-variant inlet velocity field on the resulting vane row unsteady aerodynamics are also investigated, showing that the parallel component of the aerodynamic forcing function affects only the dynamic pressure coefficient phase lag. The correlation of the dynamic pressure coefficient data with flat plate predictions is also considered. The level and chordwise distribution of the steady aerodynamic loading, not the incidence angle, are revealed to be the key parameters to obtain good correlation with such mathematical models. Author

**A86-42654#**

### EFFECTS OF S-BENDS ON DIFFUSER INTERNAL PERFORMANCE AND TURBULENCE CHARACTERISTICS

W. H. BALL and A. F. CAMPBELL (Boeing Military Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(AIAA PAPER 86-1459)

This paper presents the results from an experimental program that was conducted to investigate the effects of S-bends on diffuser internal flow behavior. The investigation was conducted using a unique test apparatus that simulates the diffuser entrance conditions behind a M sub 0 = 2.5 supersonic inlet. Results are presented from the theoretical analysis used to design the model and the experimental data obtained during the test program. The results from the program show that, although there are localized regions of separated flow present in the S-bend diffuser, the resulting effects on engine face recovery, turbulence, and distortion are small. Author

**A86-42655#**

### S-DUCT INLET/DIFFUSERS FOR TURBOPROP OFFSET GEARBOX APPLICATIONS

P. L. MCDILL (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.

(AIAA PAPER 86-1462)

A test program, utilizing a large-scale model, was run in the NASA/Lewis Research Center 10 by 10-ft wind tunnel to examine the influence on performance of design parameters of turboprop S-duct inlet/diffuser systems. The parametric test program investigated inlet lip thickness, inlet/diffuser cross-sectional geometry, throat design Mach number, and shaft fairing shape. The test program was run at angles of attack to 15 deg and tunnel Mach numbers to 0.35. Results of the program indicate that current design techniques can be used to design inlet/diffuser systems with acceptable total pressure recovery, but several of the design parameters, notably lip thickness (contraction ratio) and shaft fairing cross section, must be optimized to prevent excessive distortion at the compressor face. Author

**A86-42686#**

### CALCULATION OF ANNULAR NOZZLE TRISONIC FLOWFIELDS BY THE METHOD OF CHARACTERISTICS

B. N. WANG and J. D. HOFFMAN (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 17 p. refs

(AIAA PAPER 86-1519)

A numerical algorithm based on the unsteady two-dimensional method of characteristics is presented for calculating axisymmetric inviscid trisonic flowfields in annular nozzles. The algorithm is an explicit second-order accurate predictor-corrector procedure. An inverse marching method based on a local network of wavelines and the pathline is employed, wherein the solution grid in physical space is prespecified. An orthogonal uniform transformed space, obtained by an algebraic grid generation method, is used for flow property interpolation in the initial-data surface. Steady flow solutions are obtained as the asymptotic solution in time. Results are presented for four annular nozzles. Comparison of the predicted and measured wall pressure distributions and nozzle efficiencies show good agreement. Author

**A86-42687*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### AN LU IMPLICIT SCHEME FOR HIGH SPEED INLET ANALYSIS

S. YOON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and A. JAMESON (Princeton University, NJ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p. refs

(AIAA PAPER 86-1520)

A numerical method is developed to analyze the inviscid flowfield of a high speed inlet by the solution of the Euler equations. The LU implicit scheme in conjunction with adaptive dissipation proves to be an efficient and robust nonoscillatory shock capturing technique for high Mach nu[illegible] flows as well as for transonic flows. Author

**A86-42688*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### IMPROVED EULER ANALYSIS OF ADVANCED TURBOPROP PROPELLER FLOWS

O. YAMAMOTO, J. M. BARTON (Sverdrup Technology, Inc., Middleburg Heights, OH), and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs

(Contract NAS3-24105)

(AIAA PAPER 86-1521)

An implicit approximate factorization scheme in conjunction with a new boundary treatment was used to compute the inviscid flow field about an advanced high-speed propeller. The method of characteristics was used to apply impermeable boundary conditions. The convergence history of numerical calculations shows substantial decrease in the residual error decay. Euler solutions were computed for SR-3 propeller geometry and the results were compared with the experimental data and previous numerical results. Author

**A86-42689#**

### VSAERO ANALYSIS OF A WING/PYLON/NACELLE CONFIGURATION

W. K. LORD and S. H. ZYSMAN (United Technologies Corp., Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs

(AIAA PAPER 86-1523)

The VSAERO panel code was used to simulate the flow about a wing/pylon/nacelle configuration for which detailed experimental data were available. Good agreement between analytical and experimental pressure distributions was obtained at subsonic conditions, including prediction of relatively subtle interference effects. It was found that the accuracy of the flow solution can be adversely affected by improper panelling. Interference effects at transonic conditions were not accurately represented by the VSAERO solution, as would be expected based on the linearized-potential formulation. Author

**A86-42700#**

### NUMERICAL NAVIER-STOKES SOLUTIONS OF HIGH SPEED PROPELLER FLOWS

S. J. YOON and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. Research supported by the Virginia Center for Coal and Energy Research. refs

(AIAA PAPER 86-1538)

A numerical procedure based on the full, Reynolds averaged Navier-Stokes equations as applied to the flow near a propeller is developed. The flow is assuemd axi-symmetric, and the unsteady equations of motion are solved by MacCormack's explicit scheme. The propeller is modeled as an actuator disk, and turbulent transport is modeled by a mixing length model with a simple extension to include the effects of swirl. Computed flowfield results for the NASA/Hamilton Standrd SR1 and SR3 advanced turboprop (propfan) are compared with wind tunnel data. Good agreement was achieved with the present method. Author

**A86-42706#**

### THEORETICAL AND EXPERIMENTAL ANALYSIS OF HIGHSPEED PROPELLER AERODYNAMICS

J. M. BOUSQUET (ONERA, Chatillon-sous-Bagneux, France) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs

(AIAA PAPER 86-1549)

As part of the French CHARME research program to study high speed propellers, a 1-meter diameter propeller has been tested in the S1 Modane wind tunnel. The numerous measurements made during this test give precise data for the validation of calculation methods. Performances are compared to the results of a curved lifting line method, and analyzed with the help of pressure measurements made on spinner and nacelle. Pressures on the blades are compared to the results of a three-dimensional transonic Euler three-dimensional code. Future studies on counterrotating high speed propellers are also outlined. Author

**A86-42709*#** Lockheed-Georgia Co., Marietta.

### EVALUATION OF PROPELLER/NACELLE INTERACTIONS IN THE PTA PROGRAM

A. S. ALJABRI, V. LYMAN, and R. J. PARKER (Lockheed-Georgia Co., Marietta) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(Contract NAS3-24339)

(AIAA PAPER 86-1552)

Advanced highly-loaded propellers are proposed to power transport aircraft that cruise at high subsonic speeds giving significant fuel savings over the equivalent turbofan engine. In order to realize these savings, the propeller must be installed so that the aerodynamics of the propeller/nacelle combination do not lead to excessive cyclic blade stresses or installation losses. The on-going, NASA sponsored, Propfan Test Assessment Program (PTA) has provided the first high-speed wind-tunnel data on an installed propfan complete with an inlet. This paper presents computational techniques that allow: (1) optimization of inlet plane location, (2) contouring of lip and cowl, and (3) estimation of propeller cyclic loads due to a nonuniform flowfield. These computational methods, in spite of the complexity of the configuration and the slipstream effects, provide predictions of aerodynamic performance which are in excellent agreement with wind-tunnel data. Author

**A86-42740*#** Pennsylvania State Univ., University Park.

### A COMPARISON OF COMPUTATIONAL METHODS FOR THREE-DIMENSIONAL, TURBULENT TURBOMACHINERY FLOW FIELDS

K. R. KIRTLEY, M. WARFIELD, and B. LAKSHMINARAYANA (Pennsylvania State University, University Park) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(Contract NSG-3266)

(AIAA PAPER 86-1599)

A space-marching method and a time-marching method have been used to compute the three-dimensional turbulent flow in an end wall cascade of airfoils. Using an identical grid and turbulence model, the two codes were used to predict a variety of flow quantities. Predictions by the two methods are compared to each other and to experimental data. In general both methods predict measured quantities well, with a small edge in prediction accuracy going to the space-marching method. Secondary flow comparisons show the time-marching solution more accurately predicting the underturning of the flow in the outer portion of the end wall boundary layer while the space-marching method more accurately predicted the overturning of the flow very near the end wall. The prediction comparisons are discussed along with computational details and other attributes of the two methods. Author

**A86-42753#**

### INITIAL PERFORMANCE EVALUATION OF 2DCD EJECTOR EXHAUST SYSTEMS

D. BROOKE, D. J. DUSA, A. P. KUCHAR, and B. M. ROMINE (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p.

(AIAA PAPER 86-1615)

An ejector nozzle system can furnish the cooling flow requirement of advanced nonaxisymmetric exhaust nozzles, perhaps yielding improvements in overall propulsion system performance. An equivalent area method is presently developed on the basis of an existing axisymmetric ejector nozzle prediction program for both nozzle performance (thrust coefficient) and the air-handling characteristics of the nonaxisymmetric designs considered. A scale test model program has been conducted to determine static performance and air handling for four different two-dimensional convergent/divergent exhaust systems. Results adequate for preliminary design studies are obtained. O.C.

**A86-42756#**

### AXIAL-FLOW FAN STALLING BEHAVIOR WITH CIRCUMFERENTIAL INLET SECTORING

W. F. OBRIEN and B. M. CRAMER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 15 p. refs

(AIAA PAPER 86-1622)

The development of rotating stall in an axial-flow compressor involves circumferential flows in front of the rotor. Experiments are reported in which sectoring struts were installed to interfere with the development of the circumferential flow in a single-stage compressor. On-rotor pressure transducers and stationary probes in front of and behind the rotor were employed to study the effect of the sectoring on the stalling behavior of the stage. Experiments were conducted with and without inlet flow distortion. The sectoring struts altered to stalling behavior of the compressor, in one case changing the rotating stall pattern to multiple cell, progressive stall, and preventing the development of single-cell rotating stall. A method for measurement of the number and rotational speed of the stall cells is reported. Author

**A86-42760*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**A NUMERICAL ANALYSIS APPLIED TO HIGH ANGLE OF ATTACK THREE-DIMENSIONAL INLETS**

D. P. HWANG (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. Previously announced in STAR as N86-24658. refs
(AIAA PAPER 86-1527)

The three-dimensional analytical methods used to analyze subsonic high angle of attack inlets are described. The methods are shown to be in good agreement with experimental results for various three-dimensional high angle of attack inlets. The methods are used to predict aerodynamic characteristics of scarf and slotted-lip inlets. E.A.K.

**A86-42761#**

**CORRELATION OF THEORY AND EXPERIMENT FOR PROPFAN INLETS**

V. LYMAN and J. P. HANCOCK (Lockheed Georgia Co., Marietta, GA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1628)

Studies have indicated that the use of propfans can result in fuel savings of 20 to 25 percent relative to turbofans. Therefore, a program was initated to perform wind tunnel tests on a series of inlet models for advanced tractor, turboprop installations. Single-scoop and twin-scoop inlets and an annular inlet were tested to obtain inlet pressure recovery and distortion, external cowl surface pressures, external cowl forebody drag, and propeller blade stress data. All of the inlets were tested over a range of Mach numbers from .2 to .8 and a range of mass flow ratios. An analysis was undertaken for each of the tested propfan inlet configurations with Lockheed's QUADPAN panel program. Calculated nacelle surface pressures correlates well with experiment as long as the Mach number is low enough to preclude strong shocks on the nacelle and the scoop is large enough to be out of the low energy flow near the nacelle surface aft of the propeller spinner. The effect of the inlet interference flowfield on the propeller was calculated with Lockheed's PROPVRTX propeller analysis program. The results showed that displacing the inlet in the aft direction reduced the adverse effects on the propeller cyclic stresses. Measured propeller stress data support these results. The inlet location and contouring of the inlet lip are important design considerations that can be assessed by computational methods. Author

**A86-42762*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FLIGHT RESEARCH ON NATURAL LAMINAR FLOW NACELLES - A PROGRESS REPORT**

E. C. HASTINGS, JR., J. A. SCHOENSTER (NASA, Langley Research Center, Hampton, VA), C. J. OBARA (PRC Kentron, Inc., Hampton, VA), and S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1629)

This paper presents a progress report on an ongoing flight experiment for natural laminar flow nacelles. The results given herein were obtained during the first phase of the experiment, in which an instrumented natural laminar flow nacelle fairing was flight tested in the presence of turbofan engine noise and a controlled noise source. The results indicate that with the controlled noise source off, natural laminar flow was measured as far aft as 37 percent of the fairing length. The transition front was irregular in contour, and the extent of natural laminar flow was significantly affected by the relative flow angle for the fairing. In addition to these test results, the paper discusses the results of some recent computational analyses to predict pressure distributions and transition location, and to explain some of the data trends. Comparisons between measured and predicted data indicate that the analytical methods successfully predicted trends for the baseline (no controlled noise source) studies. Author

**A86-42822#**

**MULTI-STAGE COMPRESSOR AIRFOIL AERODYNAMICS. I - AIRFOIL POTENTIAL FLOW ANALYSIS**

H. D. JOSLYN and R. P. DRING (United Technologies Research Center, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(Contract N00014-84-C-0354)
(AIAA PAPER 86-1744)

An evaluation is made of the ability of potential flow theory to predict pressure distributions on rotor and stator airfoils in the unsteady, three-dimensional environment of a two-stage axial compressor. While excellent agreement is obtained between computational and experimental results for the core flow region, the unsteadiness and three-dimensionality produced by corner stall and rotor tip leakage can generate significant differences. It is further demonstrated, however, that the boundary layer calculations can be coupled to an approximate model for transitional and turbulent flow, together with an inferred level of freestream tubulence, in order to furnish reasonably accurate predictions of midspan loss. O.C.

**A86-42824#**

**TIP LEAKAGE REDUCTION THROUGH TIP INJECTION IN TURBOMACHINES**

M. J. POUAGARE, W. P. WEINHOLD (Duke University, Durham, NC), and K. LAZARUS AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. Army-sponsored research. refs
(AIAA PAPER 86-1746)

This paper describes an experimental study on tip leakage flow reduction through tip injection. A single blade was placed in the test section of a wind-tunnel with a gap between the tip of the blade and the top wall. Surface-streamline flow visualization, leakage flow visualization, blade static pressure measurements, and total pressure measurements behind the blade were performed in order to evaluate the effectiveness of tip injection in reducing leakage flow and losses. Two different patterns of injection were tested. It was found that the effectiveness of the tip injection depended on the injection angle and the injection-hole distribution. The study demonstrated the potential of tip injection in reducing leakage flow and losses as well as in energizing the end-wall boundary layer. Author

**A86-42825#**

**REVERSE FLOW IN MULTISTAGE AXIAL COMPRESSORS**

R. N. GAMACHE (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) and E. [illegible] GREITZER (MIT, Cambridge, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 21 p. Research supported by United Technologies Corp. and USAF. refs
(AIAA PAPER 86-1747)

This paper reports an experimental study of multistage axial compressor operation under reverse flow conditions. The experiments were performed on a high hub-tip ratio ($r_h/r_t = 0.88$) three-stage low aspect ratio axial flow compressor. Complete sets of unstalled and stalled performance characteristics are presented for two builds with different blade stagger angles. The existence of a discontinuous flow mode transition from large scale asymmetry (rotating stall) to blade-to-blade periodic ('annulus stall') at a low reverse flow coefficient is documented. The nature of the annulus stall flow was determined from high response measurements of all three velocity components and pressure at several reverse flow coefficients, using data acquisition and processing techniques developed for flows with multiple sources of periodic unsteadiness. These blade passage resolved measurements provide the first detailed kinematic picture of the flowfield structure which exists in multistage axial compressors during reverse flow operation. The experimental results reveal that the flowfield is strongly three-dimensional. In addition, the upstream measurements show a multilobed spinning acoustic disturbance pattern over a narrow range of reverse flow coefficients corresponding to a level of pressure rise equal to that in rotating stall. At this condition, the blade-to-blade periodicity disappears. Finally, it is shown that there are strong similarities in the structure of the reverse flow and rotating stall cell flowfields. Author

**A86-43110**

### APPLICATION OF LASER-DUAL-FOCUS VELOCIMETRY IN A COUNTERFLOW

P. MORAES, JR. (Centro Tecnico Aerospacial, Instituto de Atividades Espaciais, Sao Jose dos Campos, Brazil) IN: Optical methods in dynamics of fluids and solids; Proceedings of the International Symposium, Liblice, Czechoslovakia, September 17-21, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 75-82. DFG-supported research.

The flow field of a sonic jet exhausting against a supersonic mean stream was experimentally investigated using a dual-focus laser velocimeter. The experimental investigations were conducted in the 15 x 15-cm supersonic test section of the ILR wind tunnel for mainstream Mach number = 2.0 and total jet/mainstream pressure ratio = 2.0. The paper briefly describes the flow-measurement technique used and presents the flowfield details made possible through these measurements. A comparison of the measured quantities with theoretical results shows good agreement. Author

**A86-43384**

### ROTATIONAL-TRANSLATIONAL SUBSONIC MOTION OF A FINITE-SPAN WING IN AN IDEAL GAS [VRASHCHATEL'NO-POSTUPATEL'NOE DOZVUKOVOE DVIZHENIE KRYLA KONECHNOGO RAZMAKHA V IDEAL'NOM GAZE]

S. V. MINEVICH Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 34-38. In Russian. refs

An algorithm is presented for the computer calculation of the aerodynamic characteristics of a wing of arbitrary shape with an aspect ratio lambda not less than 2 in rotational-translational motion. The effect of gas compressibility is taken into account by a linearized equation. The accuracy of the calculations was checked on the example of wings of elliptical and rectangular planform in purely rotational or purely translational motion. The accuacy of the proposed method is compared with that of the methods of Karafoli (1956, 1960) and Belotserkovskii (1965). B.J.

**A86-43401**

### MATHEMATICAL MODEL OF THE INTERACTION OF A SINGLE UNSTEADY SUPERSONIC JET WITH A MOVING BARRIER OF FINITE SIZE [MATEMATICHESKAIA MODEL' VZAIMODEISTVIIA ODINOCHNOI NESTATSIONARNOI SVERKHZVUHKOVOI STRUI S PODVIZHNOI PREGRADOI KONECHNYKH RAZMEROV]

A. V. KUZNETSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 99-102. In Russian. refs

The interaction of an unsteady supersonic jet with a moving barrier of finite size placed transverse to the flow is investigated with reference to the use of pulsating flows and gasdynamic generators in various industrial processes to intensify mass transfer. A method is developed for determining the actual geometrical characteristics of the barrier, its motion in the jet, and its influence on the formation of the flow pattern. It is concluded that the proposed mathematical model is valid for arbitrary intrachamber processes and axisymmetric barriers of complex profile. B.J.

**A86-43402**

### EFFECT OF LONGITUDINAL-CONTOUR SHAPE ON THE AERODYNAMIC CHARACTERISTICS OF LIFTING BODIES AT SUPERSONIC AND HYPERSONIC FLIGHT VELOCITIES [VLIIANIE FORMY PRODOL'NOGO KONTURA NA AERODINAMICHESKIE KHARAKTERISTIKI NESUSHCHIKH KORPUSOV PRI SVERKHZVUKOVYKH I GIPERZVUKOVYKH SKOROSTIAKH POLETA]

I. I. MAZHUL Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 102-105. In Russian.

The effect of flow expansion at the rear part of a lifting body on the aerodynamic characteristics is investigated for a fixed geometry of the front part of the body. It is shown that a change in the shape of the longitudinal contour of the upper or lower surface causes an increase in the size of the lifting body without substantial losses in the maximum lift-drag ratio. B.J.

**A86-43403**

### INVESTIGATION OF THE STRUCTURE OF A SUPERSONIC JET ISSUING FROM A FREE-VORTEX NOZZLE BY MEANS OF PULSED HOLOGRAPHIC INTERFEROMETRY [ISSLEDOVANIE STRUKTURY SVERKHZVUKOVOI STRUI, ISTEKAIUSHCHEI IZ SVOBODNOVIKHREVOGO SOPLA, METODOM IMPUL'SNOI GOLOGRAFICHESKOI INTERFEROMETRII]

V. I. PANCHENKO, A. A. GILERSON, and B. S. VINOGRADOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 105-107. In Russian.

Holographic interferometry was used to study the flow of a free-vortex jet beyond the nozzle in design conditions as well as when pressures on both boundaries of the jet differed from pressures on the nozzle section. The growth of the boundary layers on the jet boundaries is studied in both design and off-design conditions for different streamline curvatures of the ideal flow. B.J.

**A86-43404**

### EXPERIMENTAL STUDY OF SUPERSONIC FLOW AROUND A SINGLE-STAGE WEDGE WITH CHEEKS AT SIDESLIP ANGLES [EKSPERIMENTAL'NOE ISSLEDOVANIE OBTEKANIIA ODNOSTUPENCHATOGO KLINA SO SHCHEKAMI SVERHZVUKOVYM POTOKOM NA UGLAKH SKOL'ZHENIIA]

V. V. DUGANOV, N. N. ZAKHAROV, and O. K. IVANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 107-110. In Russian. refs

Experimental results are presented concerning flow around a single-stage wedge with side cheeks (a configuration typical for two-dimensional supersonic intakes) at sideslip angles of 0, 5, and 10 deg. Experiments were carried out in a wind tunnel at a Mach number of 2.1, a Reynolds number of 10 to the 8th (for a characteristic dimension of 1 m), and a stagnation temperature of 288 K. The pressure distributions are examined, and the shock-wave configuration generated in the flow is discussed. B.J.

**A86-43421**

### FEATURES OF THE FLOW STRUCTURE AROUND POLYGONAL LIFTING BODIES AT SUPERSONIC VELOCITIES [OSOBENNOSTI STRUKTURY OBTEKANIIA POLIGONAL'NYKH NESUSHCHIKH KORPUSOV PRI SVERKHZVUKOVYKH SKOROSTIAKH]

I. I. MAZHUL (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), March 1986, p. 50-54. In Russian.

The flow characteristics around polygonal lifting bodies consisting of a combination of plane elements were studied experimentally at Mach numbers of 2, 3, and 4, and Reynolds numbers of 26 x 10 to the 6th, 33.5 x 10 to the 6th, and 50 x 10 to the 6th. It is shown that configurations of this type are characterized by the presence of internal shocks and boundary layer separation zones (induced by these shocks) on the lower surface. Another feature is the formation of conical vortex zones along swept lines of plane-face intersection on both upper and lower surfaces. The behavior of these features is studied in relation to the flow conditions. B.J.

**N86-28053*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**LASER FRINGE ANEMOMETRY FOR AERO ENGINE COMPONENTS**

A. J. STRAZISAR 1986 54 p Presented at the 67th Symposium of the AGARD Propulsion and Energetics Panel on Advanced Instrumentation for Aero Engine Components, Philadelphia, Pa., 19-23 May 1986

(NASA-TM-88798; E-3135; NAS 1.15:88798) Avail: NTIS HC A02/MF A01 CSCL 01A

Advances in flow measurement techniques in turbomachinery continue to be paced by the need to obtain detailed data for use in validating numerical predictions of the flowfield and for use in the development of empirical models for those flow features which cannot be readily modelled numerically. The use of laser anemometry in turbomachinery research has grown over the last 14 years in response to these needs. Based on past applications and current developments, this paper reviews the key issues which are involved when considering the application of laser anemometry to the measurement of turbomachinery flowfields. Aspects of laser fringe anemometer optical design which are applicable to turbomachinery research are briefly reviewed. Application problems which are common to both laser fringe anemometry (LFA) and laser transit anemometry (LTA) such as seed particle injection, optical access to the flowfield, and measurement of rotor rotational position are covered. The efficiency of various data acquisition schemes is analyzed and issues related to data integrity and error estimation are addressed. Real-time data analysis techniques aimed at capturing flow physics in real time are discussed. Finally, data reduction and analysis techniques are discussed and illustrated using examples taken from several LFA turbomachinery applications. Author

**N86-28054*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**MULTIAXIS AIRCRAFT CONTROL POWER FROM THRUST VECTORING AT HIGH ANGLES OF ATTACK**

F. J. CAPONE and M. L. MASON Jun. 1986 51 p Presented at the AIAA 4th Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986

(NASA-TM-87741; NAS 1.15:87741; AIAA-86-1779) Avail: NTIS HC A03/MF A01 CSCL 01A

Extensive research programs conducted at the Langley Research Center have shown that thrust vectoring can be provided by multifunction (nonaxisymmetric) nozzles. Most of this research has been conducted on pitch vectoring at both static and forward flight conditions. Recent efforts have been aimed at evaluating yaw vectoring concepts at static (wind off) conditions. This paper summarizes results for three different twin-engine fighter configurations tested over a Mach number range of 0.15 to 2.47 at angles of attack up to 35 deg. The objective of these investigations was to determine the multiaxis control power characteristics provided by thrust vectoring. All three configurations employed two-dimensional convergent-divergent nozzles which provided pitch vectoring by differential deflection of the upper and lower nozzle divergent flaps. Three different means of yaw vectoring were tested: (1) a translating nozzle sidewall; (2) yaw flaps located in the nozzle sidewalls; and (3) canted nozzles. These investigations were conducted in the Langley 16-Foot Transonic Tunnel and the Lewis 10x10-Foot Supersonic Tunnel. Longitudinal and direction control power from thrust vectoring was greater than that provided by aerodynamic control effectors at low speed or at high angles of attack. Author

**N86-28056*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HOVER IN-GROUND-EFFECT TESTING OF A FULL-SCALE, TILT-NACELLE V/STOL MODEL**

J. E. ESHLEMAN, M. R. DUDLEY, and C. J. SCHELL (Grumman Aerospace Corp., Bethpage, N.Y.) Feb. 1986 18 p Presented at the 14th AIAA Aerodynamic Testing Conference, West Palm Beach, Fla., 5-7 Mar. 1986

(NASA-TM-88218; A-86127; NAS 1.15:88218) Avail: NTIS HC A02/MF A01 CSCL 01A

A full-scale, tilt-nacelle V/STOL aircraft model was tested in hover at the National Full Scale Aerodynamics Complex (NFAC), NASA Ames Research Center. The model was powered by two TF-34 turbofan engines. It was tested at several ground heights and control deflections. Test technique and test setup were documented. Limited results show that: (1) a small change in control power with ground height was measured, and control power was found to be good over + or - 20 deg of horizontal vane deflection; (2) integrated fuselage undersurface pressures, when compared with the total model loads and measured thrust, defined the effect of the fountain and its related flow field on model forces and moments; and (3) there was no indication of hot gas ingestion during simulated takeoff in calm winds from wheels on deck ground height. Author

**N86-28057*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A PERSPECTIVE OF COMPUTATIONAL FLUID DYNAMICS**

P. KUTLER May 1986 22 p Presented at the National Aerospace Lab., Tokyo, Japan, 20 Jun. 1986

(NASA-TM-88246; A-86224; NAS 1.15:88246) Avail: NTIS HC A02/MF A01 CSCL 01A

Computational fluid dynamics (CFD) is maturing, and is at a stage in its technological life cycle in which it is now routinely applied to some rather complicated problems; it is starting to create an impact on the design cycle of aerospace flight vehicles and their components. CFD is also being used to better understand the fluid physics of flows heretofore not understood, such as three-dimensional separation. CFD is also being used to complement and is being complemented by experiments. In this paper, the primary and secondary pacing items that govern CFD in the past are reviewed and updated. The future prospects of CFD are explored which will offer people working in the discipline challenges that should extend the technological life cycle to further increase the capabilities of a proven demonstrated technology. Author

**N86-28060*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ROTOR/WING AERODYNAMIC INTERACTIONS IN HOVER**

F. F. FELKER and J. S. LIGHT May 1986 27 p Presented at the 42nd Annual Forum of the American Helicopter Society, 2-4 Jun. 1986

(NASA-TM-88255; A-86246; NAS 1.15:88255) Avail: NTIS HC A03/MF A01 CSCL 01A

An experimental and theoretical investigation of rotor/wing aerodynamic interactions in hover is described. The experimental investigation consisted of both a large-scale and small-scale test. A 0.658-scale, V-22 rotor and wing was used in the large-scale test. Wind download, wing surface pressure, rotor performance, and rotor downwash data from the large-scale test are presented. A small-scale experiment was conducted to determine how changes in the rotor/wing geometry affected the aerodynamic interactions. These geometry variations included the distance between the rotor and wing, wing incidence angle, and configurations both with the rotor axis at the tip of the wing (tilt rotor configuration) and with the rotor axis at the center of the wing (compound helicopter configuration). A wing with boundary-layer control was also tested to evaluate the effect of leading and trailing edge upper surface blowing on the wing download. A computationally efficient, semi-empirical theory was developed to predict the download on the wing. Finally, correlations between the theoretical predictions and test data are presented. Author

**N86-28062*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**PATCHED-GRID CALCULATIONS WITH THE EULER AND NAVIER-STOKES EQUATIONS: THEORY AND APPLICATIONS**
M. M. RAI Feb. 1986 105 p Presented at the Lecture Series on CFD, Rhode-St-Genese, Belgium, 3-7 Mar. 1986
(NASA-TM-88228; REPT-86112; NAS 1.15:88228) Avail: NTIS HC A06/MF A01 CSCL 01A

A patched-grid approach is one in which the flow region of interest is divided into subregions which are then discretized independently using existing grid generator. The equations of motion are integrated in each subregion in conjunction with patch-boundary schemes which allow proper information transfer across interfaces that separate subregions. The patched-grid approach greatly simplifies the treatment of complex geometries and also the addition of grid points to selected regions of the flow. A conservative patch-boundary condition that can be used with explicit, implicit factored and implicit relaxation schemes is described. Several example calculations that demonstrate the capabilities of the patched-grid scheme are also included. Author

**N86-28064*#** Old Dominion Coll., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
**AN INVESTIGATION OF THE FEASIBILITY OF ACTIVE BOUNDARY LAYER THICKENING FOR AIRCRAFT DRAG REDUCTION Final Report, period ending 3 Mar. 1986**
R. L. ASH and C. KOODALATTUPURAM Apr. 1986 15 p
(Contract NAG1-121)
(NASA-CR-177133; NAS 1.26:177133) Avail: NTIS HC A02/MF A01 CSCL 01A

The feasibility of using a forward mounted windmilling propeller to extract momentum from the flow around an axisymmetric body to reduce total drag has been studied. Numerical calculations indicate that a net drag reduction is possible when the energy extracted is returned to an aft mounted pusher propeller. However, net drag reduction requires very high device efficiencies. Results of an experimental program to study the coupling between a propeller wake and a turbulent boundary layer are also reported. The experiments showed that a complex coupling exists and simple modes for the flow field are not sufficiently accurate to predict total drag. Author

**N86-28066#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
**TRANSONIC AND SUPERSONIC WIND TUNNEL TESTS ON SCHEMATIC MISSILE CONFIGURATIONS WITH TWO DIFFERENT NOSE LENGTHS**
S. E. GUDMUNDSON and L. TORNGREN Sep. 1985 93 p
(Contract FMV-F-K-82223-75-007-07-001; FMV-F-K-82223-76-001-21-001)
(FFA-TN-1984-62; ESA-86-97051) Avail: NTIS HC A05/MF A01

A wind tunnel investigation at transonic and supersonic speeds for schematic missile models including body alone, body-tail, body-wing, and body-wing-tail configurations was performed. The test gives symmetric force and moment coefficients for an angle of attack range of 0 to 24 deg at Mach numbers from 0.7 to 2.99. Two different ogival noses with length/diameter ratio 3.5 and 1.5 were used. The influence of the nose length on normal force, pitching moment and axial force was studied. Examples of effects on asymmetric coefficients are given. ESA

**N86-28911*#** New York Univ., New York. Courant Mathematics and Computing Lab.
**COMPUTATION OF THE TRANSONIC FLOW ABOUT A SWEPT WING IN THE PRESENCE OF AN ENGINE NACELLE Research and Development Report**
D. EOSS Dec. 1985 191 p
(Contract NAG2-345; DE-AC02-76ER-03077; NSF DMS-83-20430)
(NASA-CR-177113; NAS 1.26:177113; DOE/ER-03077/267)
Avail: NTIS CSCL 01A

A method was developed to model the effects of an engine nacelle on the transonic flow about a swept wing. The nacelle is modeled by adding an inhomogeneous term, which represents a source distribution, to the potential equation, which is solved by relaxation. The method is an extension of the design code FL22INV of Bauer, Garabedian, and McFadden, which was based on Caughy and Jameson's FLO22 and on the oblique wing code FLO16. In order to obtain a sharply defined obstacle using a source distribution on a finite difference grid, a small grid size near the source was used. This was accomplished through a mapping of the flow domain to the computational domain. Once the flow is computed, the size and position of the nacelle are found by tracing streamlines. The effect of the presence of an engine nacelle on the shock waves which form about a swept wing in transonic flight. Author

**N86-28912*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**AN ANALYSIS OF BLADE VORTEX INTERACTION AERODYNAMICS AND ACOUSTICS**
D. J. LEE Sep. 1985 173 p
(Contract NCC2-149)
(NASA-CR-177016; NAS 1.26:177016; SU-JIAA-TR-67) Avail: NTIS HC A08/MF A01 CSCL 01A

The impulsive noise associated with helicopter flight due to Blade-Vortex Interaction, sometimes called blade slap is analyzed especially for the case of a close encounter of the blade-tip vortex with a following blade. Three parts of the phenomena are considered: the tip-vortex structure generated by the rotating blade, the unsteady pressure produced on the following blade during the interaction, and the acoustic radiation due to the unsteady pressure field. To simplify the problem, the analysis was confined to the situation where the vortex is aligned parallel to the blade span in which case the maximum acoustic pressure results. Acoustic radiation due to the interaction is analyzed in space-fixed coordinates and in the time domain with the unsteady pressure on the blade surface as the source of chordwise compact, but spanwise non-compact radiation. Maximum acoustic pressure is related to the vortex core size and Reynolds number which are in turn functions of the blade-tip aerodynamic parameters. Finally noise reduction and performance are considered. Author

**N86-28913*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**ANALYTICAL OBSERVATIONS ON THE AERODYNAMICS OF A DELTA WING WITH LEADING EDGE FLAPS**
S. OH and D. TAVELLA Mar. 1986 69 p
(Contract NCC2-74)
(NASA-CR-177022; NAS 1.26:177022; SU-JIAA-TR-74) Avail: NTIS HC A04/MF A01 CSCL 01A

The effect of a leading edge flap on the aerodynamics of a low aspect ratio delta wing is studied analytically. The separated flow field about the wing is represented by a simple vortex model composed of a conical straight vortex sheet and a concentrated vortex. The analysis is carried out in the cross flow plane by mapping the wing trace, by means of the Schwarz-Christoffel transformation into the real axis of the transformed plane. Particular attention is given to the influence of the angle of attack and flap deflection angle on lift and drag forces. Both lift and drag decrease with flap deflection, while the lift-to-drag ratioe increases. A simple coordinate transformation is used to obtain a closed form expression for the lift-to-drag ratio as a function of flap deflection. The main effect of leading edge flap deflection is a partial suppression of the separated flow on the leeside of the wing. Qualitative comparison with experiments is presented, showing agreement in the general trends. Author

**N86-28914*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**A STUDY OF THE FACTORS AFFECTING BOUNDARY LAYER TWO-DIMENSIONALITY IN WIND TUNNELS**
R. D. MEHTA and P. H. HOFFMANN May 1986 29 p
(Contract NCC2-294)
(NASA-CR-177023; NAS 1.26:177023; SU-JIAA-TR-66) Avail: NTIS HC A03/MF A01 CSCL 01A

The effect of screens, honeycombs, and centrifugal blowers on the two-dimensionality of a boundary layer on the test section floors of low-speed blower tunnels is studied. Surveys of the spanwise variation in surface shear stress in three blower tunnels revealed that the main component responsible for altering the spanwise properties of the test section boundary layer was the last screen, thus confirming previous findings. It was further confirmed that a screen with varying open-area ratio, produced an unstable flow. However, contrary to popular belief, it was also found that for given incoming conditions and a screen free of imperfections, its open-area ratio alone was not enough to describe its performance. The effect of other geometric parameters such as the type of screen, honeycomb, and blower were investigated. In addition, the effect of the order of components in the settling chamber, and of wire Reynolds number were also studied. Author

**N86-28915*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**THE LIFT OF SHARP-LEADING-EDGED DELTA WINGS WITH BLOWING**
D. A. TAVELLA Dec. 1985 22 p
(Contract NCC2-341)
(NASA-CR-176967; NAS 1.26:176967; JIAA-TR-68) Avail: NTIS HC A02/MF A01 CSCL 01A

An analysis of the lift augmentation due to a thin jet of air issuing from a slot along the leading edge of a delta wing is presented. The problem is treated with an extension of the method of Brown and Michael, representing the separated flow on the lee side of the wing by a pair of concentrated vortices and corresponding feeding sheets. It is assumed that the jet is not affected by Coanda forces. The analysis produces qualitative agreement with experiments. Author

**N86-28916*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
**THE USE OF A PANEL CODE ON HIGH LIFT CONFIGURATIONS OF A SWEPT FORWARD WING Final Report, 31 Sep. 1983 - 31 Mar. 1985**
J. S. SCHEIB and D. R. SANDLIN 31 Mar. 1985 70 p
(Contract NCC2-255)
(NASA-CR-176968; NAS 1.26:176968) Avail: NTIS HC A04/MF A01 CSCL 01A

A study was done on high lift configurations of a generic swept forward wing using a panel code prediction method. A survey was done of existing codes available at Ames, frow which the program VSAERO was chosen. The results of VSAERO were compared with data obtained from the Ames 7- by 10-foot wind tunnel. The results of the comparison in lift were good (within 3.5%). The comparison of the pressure coefficients was also good. The pitching moment coefficients obtained by VSAERO were not in good agreement with experiment. VSAERO's ability to predict drag is questionable and cannot be counted on for accurate trends. Further studies were done on the effects of a leading edge glove, canards, leading edge sweeps and various wing twists on spanwise loading and trim lift with encouraging results. An unsuccessful attempt was made to model spanwise blowing and boundary layer control on the trailing edge flap. The potential results of VSAERO were compared with experimental data of flap deflections with boundary layer control to check the first order effects. Author

**N86-28917*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
**IDENTIFICATION OF LINEARIZED EQUATIONS OF MOTION FOR THE FIXED WING CONFIGURATION OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT Final Report, 19 Mar. 1985 - 19 Mar. 1986**
D. L. BALOUGH and D. R. SANDLIN Mar. 1986 98 p
(Contract NCC2-258)
(NASA-CR-176977; NAS 1.26:176977) Avail: NTIS HC A05/MF A01 CSCL 01A

The purpose of this report is to establish linear, decoupled models of rigid body motion for the fixed wing configuration of the Rotor Systems Research Aircraft (RSRA). Longitudinal and lateral control surface fixed linear models were created from aircraft time histories using current system identification techniques. Models were obtained from computer simulation at 160 KCAS and 200 KCAS, and from flight data at 160 KCAS. Comparisons were performed to examine modeling accuracy, variation of dynamics with airspeed and correlation of simulation and flight data results. The results showed that the longitudinal and lateral linear models accurately predicted RSRA dynamics. The flight data results showed that no significant handling qualities problems were present in the RSRA fixed wing aircraft at the flight speed tested. Author

**N86-28918*#** Kansas Univ. Center for Research, Inc., Lawrence.
**WAKE SHAPE AND ITS EFFECTS ON AERODYNAMIC CHARACTERISTICS**
H. EMDAD and C. E. LAN Hampton, Va. NASA Jul. 1986 116 p
(Contract NAG1-134)
(NASA-CR-178118; NAS 1.26:178118) Avail: NTIS HC A06/MF A01 CSCL 01A

The wake shape under symmetrical flight conditions and its effects on aerodynamic characteristics are examined. In addition, the effect of wake shape in sideslip and discrete vortices such as strake or forebody vortex on lateral characteristics is presented. The present numerical method for airplane configurations, which is based on discretization of the vortex sheet into vortex segments, verified the symmetrical and asymmetrical roll-up process of the trailing vortices. Also, the effect of wing wake on tail planes is calculated. It is concluded that at high lift the assumption of flat wake for longitudinal and lateral-directional characteristics should be reexamined. Author

**N86-28919*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
**A COMPARISON OF COMPUTER-GENERATED LIFT AND DRAG POLARS FOR A WORTMANN AIRFOIL TO FLIGHT AND WIND TUNNEL RESULTS Final Report**
A. H. BOWERS and D. R. SANDLIN Jun. 1984 46 p
(NASA-CR-176963; NAS 1.26:176963) Avail: NTIS HC A03/MF A01 CSCL 01A

Computations of drag polars for a low-speed Wortmann sailplane airfoil are compared to both wind tunnel and flight results. Excellent correlation is shown to exist between computations and flight results except when separated flow regimes were encountered. Wind tunnel transition locations are shown to agree with computed predictions. Smoothness of the input coordinates to the PROFILE airfoil analysis computer program was found to be essential to obtain accurate comparisons of drag polars or transition location to either the flight or wind tunnel results. Author

**N86-28920*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
**COMPARISON OF THEORETICAL AND FLIGHT-MEASURED LOCAL FLOW AERODYNAMICS FOR A LOW-ASPECT-RATIO FIN Final Report, 31 Oct. 1980 - 31 Oct. 1984**
J. B. JOHNSON and D. R. SANDLIN Oct. 1984 30 p
(Contract NCC4-1)
(NASA-CR-176995; NAS 1.26:176995) Avail: NTIS HC A03/MF A01 CSCL 01A

Flight test and theoretical aerodynamic data were obtained for a flight test fixture mounted on the underside of an F-104G aircraft. The theoretical data were generated using two codes, a two dimensional transonic code called Code H, and a three dimensional subsonic and supersonic code call wing-body. Pressure distributions generated by the codes for the flight test fixture as well as boundary layer displacement thickness generated by the two dimensional code were compared to the flight test data. The two dimensional code pressure distributions compared well except at the minimum pressure point and trailing edge. Shock locations compared well except at high transonic speeds. The three dimensional code pressure distributions compared well except at the trailing edge of the flight test fixture. The two dimensional code does not predict displacement thickness of the flight test fixture well. Author

**N86-28921*#** Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
**EXPERIMENTAL ANALYSES OF TRAILING EDGE FLOWS Final Technical Report**
S. L. PETRIE and D. S. EMMER Jun. 1984 96 p
(Contract NSG-2298)
(NASA-CR-176904; NAS 1.26:176904) Avail: NTIS HC A05/MF A01 CSCL 01A

An experimental study of several of the trailing edge and wake turbulence properties for a NACA 64A010 airfoil section was completed. The experiment was conducted at the Ohio State University Aeronautical and Astronautical Research Laboratory in the 6 inch X 22 inch transonic wind tunnel facility. The data were obtained at a free stream Mach number of 0.80 and a flow Reynolds number (based on chord length) of 5 million. The principle diagnostic tool was a dual-component laser Doppler velocimeter. The experimental data included surface static pressures, chordwise and vertical mean velocities, RMS turbulence intensities, local flow angles, and a determination of turbulence kinetic energy in the wake. Two angles of attack (0 and 2 degrees) were investigated. At these incidence angles, four flow field surveys were obtained ranging in position from the surface of the airfoil, between the transonic shock and the trailing edge, to the far-wake. At both angles of attack, the turbulence intensities and turbulence kinetic energy were observed to decay in the streamwise direction. In the far wake, for the non-lifting case, the turbulence intensities were nearly isotropic. For the two degree case, the horizontal component of the turbulence intensity was observed to be substantially higher than the vertical component. Author

**N86-28922*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**MEASUREMENTS ON WING-TIP BLOWING**
D. TAVELLA, N. WOOD, and P. HARRITS Jun. 1985 41 p
(Contract NCC2-271)
(NASA-CR-176930; NAS 1.26:176930; JIAA-TR-64) Avail: NTIS HC A03/MF A01 CSCL 01A

The aerodynamics of a rectangular wing with a jet exhausting in the spanwise direction from the tips has been explored experimentally. By effectively changing the span of the wing as well as outwardly displacing the tip vortices, such jets can induce aerodynamic forces that could be used for roll and lateral control of aircraft. The concept has been investigated for a variety of jet intensities, angles of attack, and aspect ratios. The results appear to confirm theoretically predicted scaling laws for lift gain and moment generation due to blowing. Author

**N86-28923*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**A THEORY FOR LATERAL WING-TIP BLOWING**
D. TAVELLA and L. ROBERTS Jun. 1985 40 p
(Contract NCC2-271)
(NASA-CR-176931; NAS 1.26:176931; JIAA-TR-60) Avail: NTIS HC A03/MF A01 CSCL 01A

The concept of lateral blowing consists in utilizing thin jets of air, which are ejected in the spanwise direction from slots at the tips of straight and swept wings, or along the leading edges of delta wings, to generate aerodynamic forces without the assistance of deflecting solid surfaces. For weak intensities of blowing the so-generated forces could be used for roll and lateral control of aircraft. In this work a theory for this concept as applied to straight wings is presented, revealing the analytical relationship between blowing and aerodynamic forces. The approach is based on perturbing the span of an elliptically loaded wing. Scaling laws involving blowing intensity, aspect ratio, and angle of attack are derived and compared with experiments. It is concluded that this concept has potential as a novel roll and lateral control device. Author

**N86-28924*#** Waterloo Univ. (Ontario). Dept. of Applied Mathematics.
**CRITICAL EVALUATION OF THE UNSTEADY AERODYNAMICS APPROACH TO DYNAMIC STABILITY AT HIGH ANGLES OF ATTACK Final Report**
W. H. HUI Feb. 1985 46 p
(Contract NAGW-575)
(NASA-CR-177104; NAS 1.26:177104; WRI-PRO-308-07) Avail: NTIS HC A03/MF A01 CSCL 01A

Bifurcation theory is used to analyze the nonlinear dynamic stability characteristics of an aircraft subject to single-degree-of-freedom. The requisite moment of the aerodynamic forces in the equations of motion is shown to be representable in a form equivalent to the response to finite amplitude oscillations. It is shown how this information can be deduced from the case of infinitesimal-amplitude oscillations. The bifurcation theory analysis reveals that when the bifurcation parameter is increased beyond a critical value at which the aerodynamic damping vanishes, new solutions representing finite amplitude periodic motions bifurcate from the previously stable steady motion. The sign of a simple criterion, cast in terms of aerodynamic properties, determines whether the bifurcating solutions are stable or unstable. For the pitching motion of flat-plate airfoils flying at supersonic/hypersonic speed and for oscillation of flaps at transonic speed, the bifurcation is subcritical, implying either the exchanges of stability between steady and periodic motion are accompanied by hysteresis phenomena, or that potentially large aperiodic departures from steady motion may develop. Author

**N86-28925*#** National Aeronautics and Space Administration, Washington, D.C.
**AERODYNAMICS OF THE VIGGEN 37 AIRCRAFT. PART 1: GENERAL CHARACTERISTICS AT LOW SPEED**
K. KARLING Jun. 1986 145 p Transl. into ENGLISH of the book "Flygplan 37:s Aerodynamik - Part 1: Allmaent egenskaper vid Laaga Farter" Linkoeping, Sweden, SAAB-Scania, 1975 96 p Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88403; NAS 1.15:88403) Avail: NTIS HC A07/MF A01 CSCL 01A

A description of the aerodynamics of the Viggen 37 and its performances, especially at low speeds is presented. The aerodynamic requirements for the design of the Viggen 37 aircraft are given, including the basic design, performance requirement, and aerodynamic characteristics, static and dynamic load test results and flight test results. The Viggen 37 aircraft is designed to be used for air attack, surveillance, pursuit, and training applications. It is shown that this aircraft is suitable for short runways, and has good maneuvering, acceleration, and climbing characteristics. The design objectives for this aircraft were met by utilizing the effect produced by the interference between two triangular wings, positioned in tandem. Author

**N86-28926#** Oregon State Univ., Corvallis. Dept. of Mechanical Engineering.

**FIRST ORDER ANALYSIS OF THE EFFECT OF PITCHING ON THE DRAG COEFFICIENT**

R. E. WILSON and J. A. NEFF Nov. 1985 39 p
(Contract DE-AC04-76DP-00789)
(DE86-006324; SAND-85-7003) Avail: NTIS HC A03/MF A01

A first order analysis was made for the drag coefficient of a pitching NACA 0015 airfoil below stall. The inviscid velocity ditribution for a translating NACA 0015 airfoil was superimposed with the additional circulation velocity for a pitching ellipse. The resulting velocity distribution was used to numerically integrate a momentum/boundary layer formulation to obtain the drag coefficient. For both laminar and turbulent boundary layers it was found that the effect of pitching on the drag coefficient can be approximated by a shift in angle of attack. The shift angle was found to be a linear function of the pitching velocity and to be less than the induced angle of attack caused by the pitching. DOE

**N86-28927#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dir. Scientifique de la Resistance des Structures.

**EXTENSION OF A TRANSONIC THREE-DIMENSIONAL UNSTEADY SMALL PERTURBATION COMPUTING METHOD Final Report [DEVELOPPEMENT DU CODE DE CALCUL DE PETITES PERTURBATIONS TRANSSONIQUES INSTATIONNAIRES EN TRIDIMENSIONNEL]**

P. MULAK Aug. 1985 37 p In FRENCH
(Contract DRET-84-34-001)
(ONERA-RTS-23/3064-RY-048-R; ESA-86-97199) Avail: NTIS HC A03/MF A01

A method used for rigid models in unsteady flow is extended to a flexible model to compute the vibration modes. A flexible supercritical wing profile model, that of the A-310 aircraft, was tested in a wind tunnel and the results were compared to computation. The results are in good agreement, but differences with other computing methods for the first four symmetric vibration modes are discussed. ESA

**N86-28928#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics and Informatics Div.

**DESIGN OF TRANSONIC AIRFOILS WITH GIVEN PRESSURE, SUBJECT TO GEOMETRIC CONSTRAINTS**

J. M. J. FRAY, J. W. SLOOFF, J. W. BOERSTOEL, and A. KASSIES 13 Jul. 1984 36 p
(NLR-TR-84064-U; B8660349; ESA-86-97504) Avail: NTIS HC A03/MF A01

An iterative method for the design of airfoils having a prescribed pressure distribution in subsonic or transonic flow is described. In each iteration step, the difference between the current and a target pressure distributions (residual) is determined by a multigrid finite volume full-potential code. Corrections to the geometry driving the pressure residual to zero are determined by a global, inverse, thin-airfoil theory for the subsonic part of the flow field, and by a local, inverse, wavy-wall theory for the supersonic part. The geometry correction is formulated as a minimization problem in the sense that pressure distribution and geometry requirements may be balanced in a weighted least squares sense. ESA

# 03

# AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-40228**

**THE MARKET PRICE FOR AIR SAFETY**

H. A. HOPKINS International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 181-186.

An evaluation is made of the extent to which the financial and market objectives that are preeminent in the deregulated commercial environment in which many airlines now compete may affect flight safety. A comparison of fatal accident rates per million flights for the 1973-1984 period with the per capita income of various countries in 1981 appears to imply some relationship between the amount of money available and the rate of fatal accidents. Attention is given to the apportionment of responsibility for safety to airline management, the deregulated airline environment in the U.S. and questions it has raised concerning corner-cutting, and the monitoring of management performance. O.C.

**A86-40565**

**REGULATION BY THE CIVIL AVIATION AUTHORITY OF AIR SAFETY IN THE UNITED KINGDOM**

G. WHITE (Civil Aviation Authority, London, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 238-241, 302.

The functions of the Civil Aviation Authority (CAA) related to air safety in the United Kingdom are described. The CAA requires the registration and marking of aircraft, and evaluates the operation and training manuals submitted by public transport aircraft. The requirements for issuing of air operator certificates and airworthiness certificates are discussed. The licensing of flight crews, air traffic controllers, and airfields is examined. The CAA has full authority to enforce its regulations by refusing, revoking, or suspending certificates and licenses. It is also necessary for the CAA to provide air navigation services, which consist of information, directions, and facilities furnished, issued, or provided in connection with the navigation or movement of aircraft. I.F.

**A86-40567**

**POLICING AVIATION SAFETY IN THE NETHERLANDS**

R. M. SCHNITKER (Netherlands National Police Force, Aviation Investigation Dept.) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 245-254.

The monitoring of aviation safety by the aviation branch of the Dutch National Police Force is discussed. The police force is required to examine aircraft registrations and pilot qualifications at airports and other aviation locations. The procedures involved in preventing and controlling aviation accidents are described. The checking of cargo to ensure proper transportation of dangerous materials and of passengers to prevent potential aviation crimes is examined. The National Police Force coordinates their activities with local police forces, public prosecutors, and the government's aviation department in order to assure aviation safety. I.F.

**A86-41034#**

**PROTECTING ELECTRONICS AGAINST LIGHTNING GETS HARDER**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 30-32, 34.

The problem of protecting aircraft electronics from lightning strikes, when electronics are becoming both more vulnerable and more central to flight safety, is considered. Graphite composites are replacing aluminum in the skin of many aircraft, and as a result the interior electronics are not so well shielded from the 20-30-kA current of even an average lightning strike. It is noted that the FAA will soon introduce testing standards - based on present voluntary tests - for certifying that the electronics of a plane are fully shielded against lightning. A Boeing simulator will send 200-kA pulses (equal to very large lightning bolts) through full-scale aircraft. The two basic methods of protecting electronics shielding with metal and electronic isolation from induced charges - are both discussed. D.H.

**A86-41275**
**PILOT REPORT - B-1B**
M. A. KENNY (USAF, Dyess AFB, TX) Air Force Magazine (ISSN 0730-6784), vol. 69, June 1986, p. 58-62.

An account is given of the cockpit environment, flight control activities and an in-flight refueling session aboard the B-1B bomber, whose properties in these various functions derive from the extensive use of computerized control. The aircraft possesses the agility to maneuver between hills, as well as the ability to fly just above any type of terrain, in any weather. Attention is given to the crew activities associated with a low level bombing run at the Dyess Air Force Base test range. O.C.

**A86-41694*#** Massachusetts Inst. of Tech., Cambridge.
**MEASUREMENT OF ICE GROWTH DURING SIMULATED AND NATURAL ICING CONDITIONS USING ULTRASONIC PULSE-ECHO TECHNIQUES**
R. J. HANSMAN, JR. and M. S. KIRBY (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 492-498. FAA-supported research. Previously cited in issue 07, p. 842, Accession no. A86-19860. refs
(Contract NGL-22-009-640)

**A86-41695*#** National Severe Storms Lab., Norman, Okla.
**LIGHTNING STRIKES TO A NASA AIRPLANE PENETRATING THUNDERSTORMS AT LOW ALTITUDES**
V. MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK), B. D. FISHER (NASA, Langley Research Center, Hampton, VA), and J. C. GERLACH (NASA, Wallops Space Flight Center, Wallops Island, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 499-505. Previously cited in issue 07, p. 841, Accession no. A86-19637. refs

**A86-42423**
**FROM A STRIKE TO A KILL**
M. SMITH New Scientist (ISSN 0028-6664), vol. 110, May 29, 1986, p. 44-47.

Numerous bird collisions with aircraft have occurred at major airports over the past quarter century, sometimes resulting in loss of life and aircraft. The birds are sucked into the engines or collide with various parts of the aircraft. Although gulls comprise 40 percent of the problem species, difficulties also arise with lapwing (26 percent), partridges, snipes, kestrels, swallows, skylarks, etc. Wide-bodied jets are struck seven times as frequently as older, narrow-bodied aircraft. Personnel at Kennedy Airport and other airports use recorded distress calls, pyrotechnic devices and a shotgun to drive of birds. A persistent difficulty in keeping birds away is garbage dumps close to airports providing bountiful food for birds. The most effective method for warding off birds has been to keep grass around runways cut no shorter than 20 cm. The technique has been enhanced by removing earthworms from runways during rainy periods so that birds aren't drawn to the food. M.S.K.

**N86-28068*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**TIME-BASED AIR TRAFFIC MANAGEMENT USING EXPERT SYSTEMS**
L. TOBIAS and J. L. SCOGGINS Apr. 1986 59 p
(NASA-TM-88234; A-86188; NAS 1.15:88234) Avail: NTIS HC A04/MF A01 CSCL 07G

A prototype expert system was developed for the time scheduling of aircraft into the terminal area. The three functions of the air traffic control schedule advisor are as follows: first, for each new arrival, it develops an admissible flight plan for that aircraft. Second, as the aircraft progresses through the terminal area, it monitors deviations from the flight plan and provides advisories to return the aircraft to its assigned schedule. Third, if major disruptions such as missed approaches occur, it develops a revised plan. The advisor is operational on a Symbolics 3600, and is programed in MRS (a logic programming language), Lisp, and FORTRAN. Author

**N86-28069#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
**AIRCRAFT ACCIDENT REPORT: CHINA AIRLINES BOEING 747-SP, N4522V 300 NAUTICAL MILES NORTHWEST OF SAN FRANCISCO, CALIFORNIA, FEBRUARY 19, 1985**
29 Mar. 1986 48 p
(PB86-910403; NTSB-AAR-86-03) Avail: NTIS HC A03/MF A01; also available on subscription, North American continent HC $60.00/year; all others write for quote CSCL 01B

About 1016 Pacific standard time February 19, 1985, China Airlines Flight 006, a Boeing 747 SP-09, enroute to Los Angeles, California from Taipei, Taiwan, suffered an inflight upset The flight from Taipei to about 300 nmi northwest of San Francisco was uneventful and the airplane was flying at about 41,000 feet mean sea level when the No. 4 engine lost power. The National Transportation Safety Board determines that the probable cause of the accident was the captain's preoccupation with an inflight malfunction and his faiuare to monitor properly the airplane's flight instruments which resulted in his losing control of the airplane. Contributing to the accident was the captain's over-reliance on the autopilot after the loss of thrust on the No. 4 engine. GRA

**N86-28070#** National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
**AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 10 OF 1984 ACCIDENTS**
16 Dec. 1985 406 p
(PB86-916906; NTSB-AAB-86-06) Avail: NTIS HC A18/MF A01; also available on subscription, North American continent HC $185.00/year; all others write for quote CSCL 01B

Selected aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984 are given. Approximately 200 general aviation and air carrier accidents represent a random selection. The facts, conditions, circumstances and probable cause(s) for each accident are given. GRA

**N86-28929#** National Transportation Safety Board, Washington, D. C.
**ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA. US AIR CARRIER OPERATIONS: CALENDAR YEAR 1982**
1982 111 p
(PB86-212529; NTSB-ARC-86-01) Avail: NTIS HC A06/MF A01

The record of aviation accidents involving revenue operations of U.S. Air Carriers are presented, including Commuter Air Carriers and On Demand Air Taxis for calender year 1982. In 1979 and prior years, accidents involving the smaller aircraft used by Commuters and On Demand Air Taxis were reported in annual reviews of general aviation accidents. Three major sections are presented according to the federal regulations under which the flight was conducted: 14 CFR 121, 125, 127, Scheduled 14 CFR 135. In each section, tables are presented to describe the losses and characteristics of 1982 accidents to enable comparison with pior years. Author

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

**Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.**

**A86-40116#**

### INTEGRATED NAVIGATION, COMMUNICATION, AND SURVEILLANCE SYSTEMS BASED ON STANDARD DISTANCE MEASURING EQUIPMENT

A. BECKER (DFVLR, Institut fuer Flugfuehrung, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1225/a-1225/k) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 406-414. Previously cited in issue 22, p. 3183, Accession no. A84-45064. refs

**A86-40227**

### AIRPORT SURFACE NAVIGATION AND TRAFFIC CONTROL

W. L. THOMPSON (Racal Avionics, Ltd., New Malden, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 171-174.

In order to refine the control of airport surface environments to the same degree as flight environments, ATC calls for ground movement radars currently becoming available with all-weather performance and low capital costs. There remain, however, problems with radio crosstalk, interference, and various emergencies that can endanger ATC operations in a crowded airport. The development of surface navigation systems giving each pilot a visual display of the airport layout is therefore recommended. O.C.

**A86-40229**

### COMPUTERISATION OF AIR INFORMATION SERVICES IN FRANCE

R. WALLE (Service de l'Information Aeronautique, Athis-Mons, France) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 188-191, 196.

A development history and performance evaluation account is given of France's computerization of ATC data since 1979. In 1983, an aviation data base was established for the automatic editing of ATC documents and the communication of aeronautical restrictions. Attention is given to the system built for automated processing of notices to airmen, which both receives and transmits data and may be extended to such other functions as flight plan processing and the compilation of meteorological data. O.C.

**A86-40230**

### THE FRENCH AIR TRAFFIC CONTROL SYSTEM TODAY - A PARADOX

J.-P. BERNARD International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 192-196.

An evaluation is made of those aspects of the French ATC system which appear to be either more sophisticated or more backward than is currently the case in West European countries of comparable economic importance and technological advancement. The French ATC system is noted to suffer from a lack of uniform radar control for en route and approach segments of flight, giving rise to incompatibilities between both systems and working methods at various air control centers and between the centers and airport approaches. Attention is given to the French automatic air traffic coordinator, which is based on a distributed minicomputer architecture. O.C.

**A86-40569**

### RADIO TELEPHONY - A CASE FOR GROWING CONCERN

H. M. VERMEULEN International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 274-276.

The problems with and recommendations for improving aircraft communications are analyzed. The difficulties encountered in international radio communications due to language differences are discussed. The need to eliminate unnecessary distractions in the cockpit and to reduce verbal communications and traffic on busy frequencies is examined. The role of ICAO in improving aircraft communications and developing a better infrastructure is described. The use of secondary surveillance radar mode-S, which has a digital data link and provides a traffic display for the pilots, and the removal of HF frequencies as the means of civil aircraft communication are proposed as methods for enhancing aircraft communications. I.F.

**A86-40570**

### LANGUAGE PROBLEMS IN AIR TRAFFIC CONTROL

L. F. LEVESON International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 277-279.

The problems encountered in radio telephony (R/T) communications due to language difficulties are described. It is observed that rapid delivery of information, pronounced accents, and the use of slang and colloquial phrases hinder aircraft communications. The need for pilots and air traffic controllers (ATCs) to speak proper English and precisely utilize R/T phraseology is discussed. It is recommended that English be made the official R/T language, a higher standard of English proficiency stressing pronounciation and phonetics be required of pilots and ATCs, language training should take place in the area the trainee will be operating, and radio traffic be frequently monitored. I.F.

**A86-41335**

### DESIGN TECHNIQUE TO REDUCE EFFECTS OF TIDAL VARIATIONS ON AN ILS GLIDE SLOPE SYSTEM

V. UNGVICHIAN (Florida Atlantic University, Boca Raton) Electronics Letters (ISSN 0013-5194), vol. 22, April 24, 1986, p. 478, 479.

A 330 MHz null-reference glide slope system design technique to minimize the reflecting surface variations is introduced. The runaway approach end of the site selected to test this design is over an ocean. Since the ocean forms part of the reflecting surface of the glide slope system, the tidal variations will affect the glide angle. The uniform theory of diffraction is used in the analysis and calculations are made for five tidal levels from high to low tide. The results of the simulations indicate that a glide path angle exists which is least sensitive to the tidal variations. Furthermore, this optimum angle provides smooth glide path structure. Author

**A86-41873#**

### RUNWAY REQUIREMENTS IN INSTRUMENT FLIGHT TRAFFIC AT REGIONAL AIRPORTS AND COMMERCIAL LANDING AREAS [ANFORDERUNGEN AN LANDEBAHNEN FUER INSTRUMENTENFLUGBETRIEB AUF REGIONALEN VERKEHRSFLUGHAEFEN UND VERKEHRSLANDEPLAETZEN]

Ortung und Navigation (ISSN 0474-7550), vol. 27, no. 1, 1986, p. 5-28. In German. refs

Requirements pertaining to short instrument runways are studied with regard to planning criteria, lighting, and radio-electric navigation and landing aids. It is shown that instrument runways have different safety requirements from runways of large airports. The acceptance of the ICAO Annex 14 has resulted in the considerable lessening of requirements for obstacle-free surfaces, especially in the runways, the landing and takeoff surfaces, and the lateral overflight surfaces. Short instrument runways should have bright lighting at the edges, the front and end, as well as simple approach lighting. Various combinations of radio-electric landing aids are suggested. C.D.

**A86-41874#**

### SOPHISTICATION AND SAFETY IN A SEMI-AUTOMATED AIR TRAFFIC CONTROL SYSTEM

H. VON VILLIEZ (EUROCONTROL, Maastricht, Netherlands) (Royal Institute of Navigation, Meeting, 1st, Amsterdam, Netherlands, Oct. 1985) Ortung und Navigation (ISSN 0474-7550), vol. 27, no. 1, 1986, p. 29-39.

The need for data processing techniques in air traffic control (ATC) is discussed. The basic features of a semiautomated ATC system are: (1) flight path calculation, (2) event determination, (3) code allocation, (4) correlation flight-plan/radar target, (5) strip printing, and (6) ACT-message exchange. The use of a composite radar picture, single and multiradar tracking, a code-callsign correlation, an executive controller message, a short-term conflict alert, and a weather contour map for completing the operational goals of an ATC system is described. The reliability and safety requirements for ATC systems are examined. The four levels of system support include: maintenance, optimization, expansion, and replacement. The applications of mode S operation to secondary surveillance systems, and color displays and voice recognition techniques to ATC are proposed. I.F.

**A86-42966**

**FLIGHTPATH RECONSTRUCTION AND SYSTEMATIC RADAR ERROR ESTIMATION FROM MULTI-RADAR RANGE-AZIMUTH MEASUREMENTS**

J. J. RENES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), P. V.D. KRAAN (EUROCONTROL, Brussels, Belgium), and C. EYMANN (EUROCONTROL, Experimental Centre, Bretigny-sur-Orge, France) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1282-1285. refs

(Contract EUROCONTROL-A0/12/AN/82)

The MURATREC system designed to automatically monitor a complete system of radars and process data in order to produce aircraft reference trajectories is described. The system monitors up to eight radars and produces a data collection of 500,000 position measurements. The measurements are a collection of time, range, azimuth, and height information. The effects of systematic, random, and correlated errors on the MURATREC system are analyzed. The algorithms employed by the system for spline-B approximation are examined; a fast given transformation algorithm is used to compute the B-spline coefficients of the discrete least-squares fit to the uncorrected range and azimuth of the radar plot data. The system is evaluated and it is observed that MURATREC has an attainable absolute position accuracy of about 50 meters, except for steep and fast turns. I.F.

**N86-28073#** Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.

**SITING CRITERIA FOR MICROWAVE LANDING SYSTEMS (MLS) Final Report**

R. RADCLIFF and M. F. DIBENEDETTO Jun. 1986 83 p

(Contract DTRS57-83-C-00097)

(FAA/PM-86/18; OU-AEC-81-1) Avail: NTIS HC A05/MF A01

Current siting criteria for the Microwave Landing System (MLS) are described. These criteria were obtained throught flight testing, mathematical and computer modeling, and publications from other sources. A description of MLS principles and a technical description of each of the systems components are provided. General principles germane to siting, such as critical areas and propagation effects are introduced. The criteria for siting in the MLS in an ideal airport are described. Solutions to difficult siting problems such as MLS/ILS collocation, multipath and shadowing effects, and collocation with approach lighting systems are given. Author

**N86-28074*#** Boeing Commercial Airplane Co., Seattle, Wash.

**LOCAL FLOW MANAGEMENT/PROFILE DESCENT ALGORITHM. FUEL-EFFICIENT, TIME-CONTROLLED PROFILES FOR THE NASA TSRV AIRPLANE**

J. L. GROCE, K. H. IZUMI, C. H. MARKHAM, R. W. SCHWAB, and J. L. THOMPSON May 1986 126 p

(Contract NAS1-14880)

(NASA-CR-172593; NAS 1.26:172593) Avail: NTIS HC A07/MF A01 CSCL 17G

The Local Flow Management/Profile Descent (LFM/PD) algorithm designed for the NASA Transport System Research Vehicle program is described. The algorithm provides fuel-efficient altitude and airspeed profiles consistent with ATC restrictions in a time-based metering environment over a fixed ground track. The model design constraints include accommodation of both published profile descent procedures and unpublished profile descents, incorporation of fuel efficiency as a flight profile criterion, operation within the performance capabilities of the Boeing 737-100 airplane with JT8D-7 engines, and conformity to standard air traffic navigation and control procedures. Holding and path stretching capabilities are included for long delay situations. Author

**N86-28930#** IIT Research Inst., Annapolis, Md.

**A COMPARISON OF THE EFFECTS OF TWO TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEMS (TCAS 3 AND TCAS 2) ON THE PERFORMANCE OF THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM Final Report, May 1984 - Mar. 1986**

T. OGRADY, D. KATZ, and C. CORSE Apr. 1986 44 p

(Contract F19628-85-C-0071)

(DOT/FAA/PM-86/8; ECAC-CR-86-027) Avail: NTIS HC A04/MF A01

An analysis was performed to predict the effects of the Traffic Alert and Collision Avoidance System (TCAS 3) on the performance of the Air Traffic Control Radar Beacon System (ATCRBS) in the Los Angeles Basin. This was accomplished by comparing the effects of TCAS 3 and TCAS 2 operations on airborne transponder and ground-based ATCRBS interrogator performance in the same hypothetical peak Los Angeles Basin aircraft deployment. Author

**N86-28931*#** Analytical Mechanics Associates, Inc., Mountain View, Calif.

**EVALUATION OF THE USEFULNESS OF VARIOUS SIMULATION TECHNOLOGY OPTIONS FOR TERPS ENHANCEMENT**

A. V. PHATAK and J. A. SORENSEN May 1986 33 p

(Contract NAS2-11973)

(NASA-CR-177408; NAS 1.26:177408; FAA/PM-86/15; AMA-86-2-II) Avail: NTIS HC A03/MF A01 CSCL 17G

Current approved terminal instrument procedures (TERPS) do not permit the full exploitation of the helicopter's unique flying characteristics. Enhanced TERPS need to be developed for a host of non-standard landing sites and navigation aids. Precision navigation systems such as microwave landing systems (MLS) and the Global Positioning System (GPS) open the possibility of curved paths, steep glide slopes, and decelerating helicopter approaches. This study evaluated the feasibility, benefits, and liabilities of using helicopter cockpit simulators in place of flight testing to develop enhanced TERPS criteria for non-standard flight profiles and navigation equipment. Near-term (2 to 5 year) requirements for conducting simulator studies to verify that they produce suitable data comparable to that obtained from previous flight tests are discussed. The long-term (5 to 10 year) research and development requirements to provide necessary modeling for continued simulator-based testing to develop enhanced TERPS criteria are also outlined. Author

**N86-28932#** Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.

**INVESTIGATIONS FOR IMPROVING OPERATIONAL RELIABILITY AND MAINTAINABILITY OF ILS COMPONENTS. VOLUME 2: FIGURES AND ILLUSTRATIONS Final Report, Feb. 1983 - Feb. 1986**

R. H. MCFARLAND, W. D. PHIPPS, L. D. BRADY, J. DENNIS, and J. D. LONGWORTH Feb. 1986 376 p

(Contract DTFA01-83-C-20025)

(FAA/PM-86/7.11-VOL-2; OU/AEC/EER-79-1-VOL-2) Avail: NTIS HC A17/MF A01

Evaluations and performance analysis of the Instrument Landing System (ILS) are presented for Dallas-Fort Worth, Tex.; Wheeling, W.V.; Bristol, Tenn.; Parkersburg, W.V.; Pontiac, Mich.; and DeKalb-Peachtree, Ga. An investigation of anomalous performance of the glide slope at Lambert-St. Louis is reported. An analysis of Instrument Landing System (ILS) Reference Datum Heights (RDH) is reported, as well as the results of an investigation of glide slope critical areas. A study into the feasibility of developing ground-based checking techniques for validating the Sideband Reference (SBR) glide slope is presented, as well as an assessment of the current standards and tolerances used to qualify glide slope structures. In addition, a proposed methodology for mathematical model validation is discussed. Author

**N86-28933*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**DESIGN CONSIDERATIONS FOR FLIGHT TEST OF A FAULT INFERRING NONLINEAR DETECTION SYSTEM ALGORITHM FOR AVIONICS SENSORS**
A. K. CAGLAYAN (Charles River Analytics, Inc., Cambridge, Mass.), P. M. GODIWALA, and F. R. MORRELL Aug. 1986 11 p Presented at the Guidance, Navigation, and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88998; NAS 1.15:88998) Avail: NTIS HC A02/MF A01 CSCL 01D

The modifications to the design of a fault inferring nonlinear detection system (FINDS) algorithm to accommodate flight computer constraints and the resulting impact on the algorithm performance are summarized. An overview of the flight data-driven FINDS algorithm is presented. This is followed by a brief analysis of the effects of modifications to the algorithm on program size and execution speed. Significant improvements in estimation performance for the aircraft states and normal operating sensor biases, which have resulted from improved noise design parameters and a new steady-state wind model, are documented. The aircraft state and sensor bias estimation performances of the algorithm's extended Kalman filter are presented as a function of update frequency of the piecewise constant filter gains. The results of a new detection system strategy and failure detection performance, as a function of gain update frequency, are also presented. Author

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-40106*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**COMPUTER SIZING OF FIGHTER AIRCRAFT**
P. G. COEN and W. E. FOSS, JR. (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 353, 354. Previously announced in STAR as N85-16759. refs
(AIAA PAPER 85-0212)

The computer sizing technique has been applied to a number of military mission profiles. Performance data can be determined for all segments of the selected profile, which typically include takeoff, climb, cruise, loiter, reserve and landing segments. Options are available for detailed calculation of combat performance and energy-maneuverability characteristics. Configuration changes, such as external fuel tank drop and weapon expenditure, can be included in the mission. In the sizing mode, aircraft gross weight, wing loading, and thrust-to-weight ratio are varied automatically to determine which combinations meet the design mission radius. The resulting performance data can be used to create a thumbprint plot. This plot is useful in determining the configuration size that best satisfies the mission and performance requirements. The sizing mode can also be used to perform parametric studies such as sensitivity of gross weight to alternate design conditions. Author

**A86-40113#**
**CTOL SKI JUMP - ANALYSIS, SIMULATION, AND FLIGHT TEST**
J. W. CLARK, JR. and M. M. WALTERS (U.S. Navy, Naval Air Development Center, Warminster, PA) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 382-389.

In the past several years, the ski-jump (ramp-assisted) launch concept has received considerable attention within the U.S. Navy. The specific goal was set (and achieved) to demonstrate through flight test the feasibility of, and quantify performance gains from, ski-jump launch of the T-2C, F-14A, and F/A-18A aircraft using a 100-ft ramp with variable end angles of 6 and 9 degs. The analysis, piloted simulation, performance predictions, and flight safety considerations leading to flight test, as well as a comparison of analytical predictions with flight test results for the three aircraft, are discussed. The developed analytical capability, although somewhat conservative, proved to be highly effective in preparation for, and support of, the flight test and successfully predicting the 40-60 percent reduction in takeoff distance demonstration in flight test. Author

**A86-40114#**
**A COMPUTER-AUGMENTED PROCEDURE FOR COMMERCIAL AIRCRAFT CONFIGURATION DEVELOPMENT AND OPTIMIZATION**
C. HABERLAND, W. FENSKE (Berlin, Technische Universitaet, West Germany), and J. THORBECK (Deutsche Lufthansa AG, Hamburg, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 943-953) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 390-397. Previously cited in issue 22, p. 3188, Accession no. A84-45031. refs

**A86-40471**
**BEECH'S ENTERPRISING STARSHIP**
G. WARWICK Flight International (ISSN 0015-3710), vol. 129, May 3, 1986, p. 18-24.

The design and development of a new corporate turboprop, the Beech Starship 1, are described. Starship 1 is an eight-to-ten seat business turboprop aimed at the lower end of the business jet market, cruising at up to 41,000 ft and 405 mph (but not simultaneously), with a still-air range of 2250 nautical miles (enough for a nonstop flight across the U.S.), and the ability to operate out of airfields too small for jets. The design features an aft-set swept wing with rudder-equipped winglets for directional control, combined with a slender foreplane - a canard configuration or tandem wing. The airframe is almost entirely composite. Fuel efficiency is claimed to at least 25 percent better than a jet of comparable size. D.H.

**A86-40472**
**NACES - TODAY'S ULTIMATE SEAT**
M. GAINES Flight International (ISSN 0015-3710), vol. 129, May 3, 1986, p. 26-29.

The Martin-Baker Mk.14 Naces (Navy Aircrew Common Ejection Seat) is described. The Naces, to be built by Martin-Baker and produced by a U.S. company to be chosen by Martin-Baker, is to be fitted to A-6E Intruders (the new-build upgraded variant), the F-14D Tomcat, the F-18 Hornet, and the T-45A Goshawk two-seat trainer. The Navy's list of criteria, besides high performance, included low acquisition cost, commonality, ease of production, extreme ease of maintenance, high reliability, low life-cycle costs, minimum program risk, a pre-planned product improvement program for future growth and integrated logistic support. Details of construction (explosive cartridge, electronic sequencer, rocket deployment of parachute, etc.) are covered. It is noted that a safe ejection will be possible from an aircraft with nose level at 130-knot airspeed and 110 feet of altitude, with the aircraft inverted. D.H.

**A86-41688#**
**CANARD/TAIL COMPARISON FOR AN ADVANCED VARIABLE-SWEEP-WING FIGHTER**
J. P. LANDFIELD and D. RAJKOVIC (Grumman Aerospace Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 449-454. Previously cited in issue 03, p. 257, Accession no. A85-13510. refs

**A86-41692#**

**DESIGN OF A CARBON-FIBER REINFORCED WING FOR THE ALPHA-JET MAJOR PANEL TESTS**

D. ROSE, E. HENZE (Dornier GmbH, Friedrichshafen, West Germany), D. WURZEL, and H. SCHELLING (DFVLR, Stuttgart, West Germany) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 446-453) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 477-483. Previously cited in issue 13, p. 1848, Accession no. A85-30278.

**A86-41696*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A FORWARD-SWEPT-WING FIGHTER CONFIGURATION DESIGNED BY A TRANSONIC COMPUTATIONAL METHOD**

M. J. MANN and C. E. MERCER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 506-512. Previously cited in issue 01, p. 10, Accession no. A86-11035. refs

**A86-41710*#** Old Dominion Univ., Norfolk, Va.

**THE INFLUENCE OF SOURCE LOCATION ON THE STRUCTURAL-ACOUSTIC INTERACTION OF CYLINDERS**

J. J. KELLY (Old Dominion University, Norfolk, VA) and C. R. FULLER (Virginia Polytechnic Institute and State University, Blackburg) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 609-616) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 955-961. Previously cited in issue 13, p. 1899, Accession no. A85-30390. refs
(Contract NAG1-390)

**A86-41976#**

**THE CYCLO-CRANE - A HYBRID AIRSHIP CONCEPT**

J. J. MORRIS (Aerolift, Inc., Tillamook, OR) Airship, Dec. 1985, p. 9-11.

The 'Cyclo-Crane' is an aerostat that incorporates aerodynamic lift and thrust elements in order to furnish heavy lift services comparable to those of the helicopter, though at lower cost. While the Cyclo-Crane demonstration vehicle carries a 2-ton slung payload, its full size version will be capable of operations with 25 tons. Standard aircraft engines are used in what may be characterized as a tip-driven rotor configuration; VTOL capabilities are available with any two of the four engines operating. Forward movement from the hovering position is achieved by altering the pitch of the rotor blade airfoils. O.C.

**A86-41977#**

**A THEORETICAL STUDY OF DELTOID PLANFORMS OPERATING IN THE GROUND EFFECT REGION**

D. SHELDON and W. PUTNAM (Aereon Corp., Princeton, NJ) Airship, Dec. 1985, p. 11-15.

**A86-42704*#** Garrett Turbine Engine Co., Phoenix, Ariz.

**ADVANCED TECHNOLOGY PAYOFFS FOR FUTURE ROTORCRAFT, COMMUTER AIRCRAFT, CRUISE MISSILE, AND APU PROPULSION SYSTEMS**

M. A. TURK and P. K. ZEINER (Garrett Turbine Engine Co., Phoenix, AZ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. Army-supported research.
(Contract NAS3-24544)
(AIAA PAPER 86-1545)

In connection with the significant advances made regarding the performance of larger gas turbines, challenges arise concerning the improvement of small gas turbine engines in the 250 to 1000 horsepower range. In response to these challenges, the NASA/Army-sponsored Small Engine Component Technology (SECT) study was undertaken with the objective to identify the engine cycle, configuration, and component technology requirements for the substantial performance improvements desired in year-2000 small gas turbine engines. In the context of this objective, an American turbine engine company evaluated engines for four year-2000 applications, including a rotorcraft, a commuter aircraft, a supersonic cruise missile, and an auxiliary power unit (APU). Attention is given to reference missions, reference engines, reference aircraft, year-2000 technology projections, cycle studies, advanced engine selections, and a technology evaluation. G.R.

**A86-42829*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HELICOPTER ROTOR AND ENGINE SIZING FOR PRELIMINARY PERFORMANCE ESTIMATION**

P. D. TALBOT, J. V. BOWLES, and H. C. LEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 17 p. refs
(AIAA PAPER 86-1756)

Methods are presented for estimating some of the more fundamental design variables of single-rotor helicopters (tip speed, blade area, disk loading, and installed power) based on design requirements (speed, weight, fuselage drag, and design hover ceiling). The well-known constraints of advancing-blade compressibility and retreating-blade stall are incorporated into the estimation process, based on an empirical interpretation of rotor performance data from large-scale wind-tunnel tests. Engine performance data are presented and correlated with a simple model usable for preliminary design. When approximate results are required quickly, these methods may be more convenient to use and provide more insight than large digital computer programs. Author

**A86-43002**

**APPLICATION OF SYSTEM IDENTIFICATION TO AIRCRAFT FLIGHT TEST DATA PROCESSING**

L. C. ANDERSON and J. H. VINCENT (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1929-1931.

A parameter identification technique for developing an aerodynamic model of the AV-8B aircraft with flight test data is described. The methods utilized to generate the model parameters, which include cubic spline functions, an equation error technique, and equation error/regression methods, are discussed. The test data was collected from flight maneuver tests involving 23 maneuvers of 30 sec durations. The determination of the model structure is examined. A principal components regression algorithm is applied to the identification of the model parameters. Nonlinear aerodynamic coefficients for yawing moment due to sideslip, yawing moment versus sideslip, rolling moment due to aileron, and rolling moment due to roll rate are identified. The flight test identified model is compared to wind tunnel data and good correlation is detected. I.F.

**A86-43380**

**INFLUENCE OF STRUCTURAL CHANGES ON THE FUEL-CONSUMPTION EFFICIENCY OF A TRANSPORT AIRCRAFT [VLIIANIE KONSTRUKTIVNYKH IZMENENII NA TOPLIVNUIU EFFEKTIVNOST' TRANSPORTNOGO SAMOLETA]**

V. P. GOGOLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 19-22. In Russian.

Formulas are obtained for determining the final change in the fuel mass on an aircraft as changes in the masses of the aircraft components are carried out. The fuel-mass and aircraft-mass criteria are compared in terms of the significance of drag changes. B.J.

**A86-43385**

**THEORY OF THE MOTION OF PROPELLER BLADES FOR LARGE DISPLACEMENTS [TEORIIA DVIZHENIIA LOPASTEI NESUSHCHEGO VINTA PRI BOL'SHIKH PEREMESHCHENIIAKH]**

V. A. PAVLOV and S. A. MIKHAILOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 39-42. In Russian. refs

A method is proposed for deriving the equations of motion of propeller blades in a flow for large displacements. The mathematical model of a blade being deformed by an arbitrary load is constructed on the basis of spatial-straight-line theory. The external-load components are determined from the deformation grid. B.J.

**A86-43389**

**LAYOUT OF ELECTRICAL EQUIPMENT ON AN AIRCRAFT WITH ALLOWANCE FOR EQUIPMENT SIZE CONSTRAINTS IN THE FRAMEWORK OF COMPUTER-AIDED DESIGN [KOMPONOVKA I RAZMESHCHENIIE ELEKTROKONSTRUKTSII NA SAMOLETE S UCHETOM OGRANICHENII NA IKH OBE'MY PRI AVTOMATIZIROVANNOM PROEKTIROVANII]**

V. S. TERESHCHUK and V. P. GORIACHKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 57-61. In Russian. refs

Dynamic programming is used to solve the layout problem for the secondary power supply system on an aircraft, with allowance for size constraints. The method used can serve as the basis for the program module in a system for the computer-aided design of aircraft electrical equipment. B.J.

**N86-28075*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LOADS CALIBRATIONS OF STRAIN GAGE BRIDGES ON THE DAST PROJECT AEROELASTIC RESEARCH WING (ARW-2)**

C. V. ECKSTROM Mar. 1986 118 p
(NASA-TM-87677; NAS 1.15:87677) Avail: NTIS HC A06/MF A01 CSCL 01C

Results from and details of the procedure used to calibrate strain gage bridges for measurements of wing structural loads, shear (V), bending moment (M), and torque (T), at three semispan stations on both the left and right semispans of the ARW-2 wing are presented. The ARW-2 wing has a reference area of 35 square feet, a span of 19 feet, an aspect ratio of 10.3, a midchord line sweepback angle of 25 degrees, and a taper ratio of 0.4. The ARW-2 wing was fabricated using aluminum spars and ribs covered with a fiberglass/honeycomb sandwich skin material. All strain gage bridges are mounted along with an estimate of their accuracy by means of a comparison of computed loads versus actual loads for three simulated flight conditions. Author

**N86-28076*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NASTRAN/FLEXSTAB PROCEDURE FOR STATIC AEROELASTIC ANALYSIS**

L. S. SCHUSTER Sep. 1984 21 p
(NASA-TM-84897; NAS 1.15:84897) Avail: NTIS HC A02/MF A01 CSCL 01C

Presented is a procedure for using the FLEXSTAB External Structural Influence Coefficients (ESIC) computer program to produce the structural data necessary for the FLEXSTAB Stability Derivatives and Static Stability (SD&SS) program. The SD&SS program computes trim state, stability derivatives, and pressure and deflection data for a flexible airplane having a plane of symmetry. The procedure used a NASTRAN finite-element structural model as the source of structural data in the form of flexibility matrices. Selection of a set of degrees of freedom, definition of structural nodes and panels, reordering and reformatting of the flexibility matrix, and redistribution of existing point mass data are among the topics discussed. Also discussed are boundary conditions and the NASTRAN substructuring technique. Author

**N86-28077*#** McDonnell-Douglas Corp., Long Beach, Calif.

**EVALUATION OF LAMINAR FLOW CONTROL SYSTEMS CONCEPTS FOR SUBSONIC COMMERCIAL TRANSPORT AIRCRAFT Final Report**

W. E. PEARCE Jun. 1983 504 p
(Contract NAS1-14632)
(NASA-CR-159251; NAS 1.26:159251; ACEE-01-FR-3132) Avail: NTIS HC A22/MF A01 CSCL 01C

An evaluation was made of laminar flow control (LFC) system concepts for subsonic commercial transport aircraft. Configuration design studies, performance analyses, fabrication development, structural testing, wind tunnel testing, and contamination-avoidance techniques were included. As a result of trade studies, a configuration with LFC on the upper wing surface only, utilizing an electron beam-perforated suction surface, and employing a retractable high-lift shield for contamination avoidance, was selected as the most practical LFC system. The LFC aircraft was then compared with an advanced turbulent aircraft designed for the same mission. This comparison indicated significant fuel savings and reduced direct operating cost benefits would result from using LFC. Author

**N86-28078*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**APPLICATION OF PARAMETER ESTIMATION TO HIGHLY UNSTABLE AIRCRAFT**

R. E. MAINE and J. E. MURRAY Aug. 1986 14 p Proposed for presentation at the AIAA Atmospheric Flight Mechanics Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88266; H-1365; NAS 1.15:88266; AIAA-86-2020-CP) Avail: NTIS HC A02/MF A01 CSCL 01C

The application of parameter estimation to highly unstable aircraft is discussed. Included are a discussion of the problems in applying the output error method to such aircraft and demonstrates that the filter error method eliminates these problems. The paper shows that the maximum likelihood estimator with no process noise does not reduce to the output error method when the system is unstable. It also proposes and demonstrates an ad hoc method that is similar in form to the filter error method, but applicable to nonlinear problems. Flight data from the X-29 forward-swept-wing demonstrator is used to illustrate the problems and methods discussed. Author

**N86-28079*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EFFECTS OF BLADE-TO-BLADE DISSIMILARITIES ON ROTOR-BODY LEAD-LAG DYNAMICS**

M. J. MCNULTY Mar. 1986 31 p
(Contract K-1053)
(NASA-TM-86828; A-85393; NAS 1.15:86828; USAAVSCOM-TM-86-A-3) Avail: NTIS HC A03/MF A01 CSCL 01C

Small blade-to-blade property differences are investigated to determine their effects on the behavior of a simple rotor-body system. An analytical approach is used which emphasizes the significance of these effects from the experimental point of view. It is found that the primary effect of blade-to-blade dissimilarities is the appearance of additional peaks in the frequency spectrum which are separated from the convention response modes by multiples of the rotor speed. These additional responses are potential experimental problems because when they occur near a mode of interest they act as contaminant frequencies which can make damping measurements difficult. The effects of increased rotor-body coupling and a rotor shaft degree of freedom act to improve the situation by altering the frequency separation of the modes. Author

**N86-28080#** Aeronautical Research Labs., Melbourne (Australia).

**MIRAGE A3-002 STRAIN RESPONSES TO GROUND CALIBRATION LOADINGS BETWEEN 1978 AND 1985**

M. G. J. HIGGS Dec. 1985 116 p
(AD-A165846; ARL-STRUC-TM-425) Avail: NTIS HC A06/MF A01 CSCL 01C

Prior to flight trials in 1978, a calibration of strain gauges fitted to Mirage A3-002 was carried out by measuring responses to ground loads applied at several locations on the Mirage wing. Since 1978, further ground calibrations have been made on the same aircraft. The loading procedure used was similar to that for earlier ground calibrations of other Mirage aircraft. This technical memorandum provides a record of the output of strain gauges fitted to A3-002, and identifies some trends in these outputs. For some gauges, data is given for a seven-year period. Two loading cases are presented: (1) loading at the main external store attachment point, and (2) loading at the Sidewinder attachment point. The discussion is restricted to strain gauges fitted to wings and to fuselage frame 26. In general, consistent results were obtained over the measurement period. GRA

**N86-28081#** Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.

**PROBABILISTIC DAMAGE TOLERANCE ANALYSIS OF AIRCRAFT STRUCTURES**

B. PALMBERG, A. F. BLOM, and S. EGGWERTZ Nov. 1985 136 p Submitted for publication
(Contract STU-84-4563)
(FFA-TN-1985-68; ESA-86-97055) Avail: NTIS HC A07/MF A01

The state of the art in probabilistic damage tolerance analysis was reviewed. A probabilistic model for fatigue life prediction based on existing models for probabilistic characterization of initial flaw sizes, fatigue crack growth and failure was developed. The effect of periodic inspections is taken into account. A numerical example which shows practical difficulties involved in the analysis, but also the advantage of inspections from a safety point of view is included. ESA

**N86-28082#** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.

**THE DESIGN OF COMPOSITE STRUCTURES [LA CONCEPTION DES STRUCTURES COMPOSITES]**

G. HELLARD 13 Feb. 1985 22 p In FRENCH Presented at 1st Bonded Aircraft Struct. Tech. Appl. and Repairs Tech. Congr., Seeheim, West Ger., 23 Jan. 1985
(SNIAS-861-111-103; GCO/GH/CL-442.026/85; ESA-86-97140)
Avail: NTIS HC A02/MF A01

The principles of aircraft element design using composite materials are outlined. Glass carbon and Kevlar composites are discussed. Sandwich and monolothic structures are described and application criteria are detailed. Drawings detailing the composite elements of the A-310 to A-330 and ATR-42 aircrafts and the particular design of those elements are presented. ESA

**N86-28083#** Societe Nationale Industrielle Aerospatiale, Toulouse (France).

**THE SIGMA CADCAM SOFTWARE [SIGMA, LOGICIEL DE CFAO]**

R. GANDOU and P. JUBERT 16 Dec. 1985 14 p In FRENCH Presented at Congr. on Le Calcul Domain, Grenoble, France, 6 Dec. 1985 Submitted for publication
(SNIAS-861-111-110; ESA-86-97146) Avail: NTIS HC A02/MF A01

A software system for designing and handling complex three-dimensional shapes based on a polynomial representation of curves and surfaces derived from Bezier-Berstein functions is described. Applications include aviation (designing wings, forward fuselages, wing-fuselage joints, engine pods and pylons) ship building (designing hulls) the automobile industry (bodywork), and all industries for which the design of shapes raises complex problems, requiring considerable interactivity, extremely good computation accuracy, and manipulation of surfaces by blending, cutting out, etc. The man machine dialog; the creation of shapes; the exploitation of shapes; and manufacture are discussed. ESA

**N86-28084#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Structures Dept.

**COMPUTING CODES FOR DEVELOPMENT OF HELICOPTER CRASHWORTHY STRUCTURES AND TEST SUBSTANTIATION**

J. MENS and J. C. BIANCHINI (Engineering System International, Rungis, France) 1986 14 p Presented at AHS/NAI Intern. Seminar, Nanjing, China, 6-8 Jan. 1985 Sponsored by Direction des Recherches Etudes et Techniques
(SNIAS-861-210-106; ESA-86-97154) Avail: NTIS HC A02/MF A01

Computing tools used in designing crashworthy helicopters are described. The dynamic behavior of components during impact on ground is computed by the KRASH program. The buckling load of panels stiffened by angles, Z-sections, or honeycomb panels, is computed by a purely analytic computer code. The complete buckling and post-buckling behavior of the structure components can be successfully described by the PAM CRASH computer program system, taking account of specific support and contact conditions as well as possible interaction between fluid and structure; the programs use the finite element method in large deformations and the nonlinear behavior of materials. In static or slightly dynamic analyses, an implicit integration scheme is used. For higher velocity impact, an explicit scheme is more effective. Hybridization of the analytical model within an implicit numerical code gives results which are very comparable with a purely numerical calculation, but at lower cost. ESA

**N86-28935*#** Massachusetts Inst. of Tech., Cambridge.

**FORMAL OPTIMIZATION OF HOVERING PERFORMANCE USING FREE WAKE LIFTING SURFACE THEORY**

S. Y. CHUNG Feb. 1986 260 p
(Contract NAG2-275)
(NASA-CR-177103; NAS 1.26:177103) Avail: NTIS HC A12/MF A01 CSCL 01C

Free wake techniques for performance prediction and optimization of hovering rotor are discussed. The influence functions due to vortex ring, vortex cylinder, and source or vortex sheets are presented. The vortex core sizes of rotor wake vortices are calculated and their importance is discussed. Lifting body theory for finite thickness body is developed for pressure calculation, and hence performance prediction of hovering rotors. Numerical optimization technique based on free wake lifting line theory is presented and discussed. It is demonstrated that formal optimization can be used with the implicit and nonlinear objective or cost function such as the performance of hovering rotors as used in this report. Author

**N86-28936*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronatuical Engineering.

**DEVELOPMENT OF FLIGHT TESTING TECHNIQUES Final Report, 31 Oct. 1979 - 31 Oct. 1984**

D. R. SANDLIN Oct. 1984 9 p
(Contract NCC4-1)
(NASA-CR-176996; NAS 1.26:176996) Avail: NTIS HC A02/MF A01 CSCL 01C

A list of students involved in research on flight analysis and development is given along with abstracts of their work. The following is a listing of the titles of each work: Longitudinal stability and control derivatives obtained from flight data of a PA-30 aircraft; Aerodynamic drag reduction tests on a box shaped vehicle; A microprocessor based anti-aliasing filter for a PCM system; Flutter prediction of a wing with active aileron control; Comparison of theoretical and flight measured local flow aerodynamics for a low aspect ratio fin; In flight thrust determination on a real time basis; A comparison of computer generated lift and drag polars for a Wortmann airfoil to flight and wind tunnel results; and Deep stall flight testing of the NASA SGS 1-36. E.R.

**N86-28937*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronatuical Engineering.
**IN-FLIGHT THRUST DETERMINATION ON A REAL-TIME BASIS Final Report**
R. J. RAY, T. CARPENTER, and T. SANDLIN Apr. 1984 39 p
(Contract NCC4-1)
(NASA-CR-176997; NAS 1.26:176997) Avail: NTIS HC A03/MF A01 CSCL 01C

A real time computer program was implemented on a F-15 jet fighter to monitor in-flight engine performance of a Digital Electronic Engine Controlled (DEES) F-100 engine. The application of two gas generator methods to calculate in-flight thrust real time is described. A comparison was made between the actual results and those predicted by an engine model simulation. The percent difference between the two methods was compared to the predicted uncertainty based on instrumentation and model uncertainty and agreed closely with the results found during altitude facility testing. Data was obtained from acceleration runs of various altitudes at maximum power settings with and without afterburner. Real time in-flight thrust measurement was a major advancement to flight test productivity and was accomplished with no loss in accuracy over previous post flight methods. Author

**N86-28939*#** Boeing Commercial Airplane Co., Seattle, Wash.
**DESIGN REQUIREMENTS AND DEVELOPMENT OF AN AIRBORNE DESCENT PATH DEFINITION ALGORITHM FOR TIME NAVIGATION Final Report**
K. H. IZUMI, J. L. THOMPSON, J. L. GROCE, and R. W. SCHWAB May 1986 67 p
(Contract NAS1-16300)
(NASA-CR-178037; NAS 1.26:178037) Avail: NTIS HC A04/MF A01 CSCL 17G

The design requirements for a 4D path definition algorithm are described. These requirements were developed for the NASA ATOPS as an extension of the Local Flow Management/Profile Descent algorithm. They specify the processing flow, functional and data architectures, and system input requirements, and recommended the addition of a broad path revision (reinitialization) function capability. The document also summarizes algorithm design enhancements and the implementation status of the algorithm on an in-house PDP-11/70 computer. Finally, the requirements for the pilot-computer interfaces, the lateral path processor, and guidance and steering function are described. Author

**N86-28940*#** Boeing Commercial Airplane Co., Seattle, Wash.
**AN INVESTIGATION OF TNAV EQUIPPED AIRCRAFT IN A SIMULATED EN ROUTE METERING ENVIRONMENT Final Report**
J. L. GROCE, K. H. IZUMI, C. H. MARKHAM, R. W. SCHWAB, and J. A. TAYLOR 5 May 1986 98 p
(Contract NAS1-16300)
(NASA-CR-178031; NAS 1.26:178031; D6-52321) Avail: NTIS HC A05/MF A01 CSCL 01C

This document presents the results of an effort to estimate how often a TNAV (Time Navigation) equipped aircraft could be given a TNAV clearance in the En Route Metering (ERM) system as a function of the percentage of arriving traffic which is TNAV equipped. A fast-time simulation of Denver Stapleton international arrival traffic in the Denver Air Route Traffic Control Center route structure, including en route metering operations, was used to develop data on estimated conflicts, clearance communications and fuel usage for traffic mixes of 25, 50, 75 and 100% TNAV equipped. This study supports an overall effort by NASA to assess the benefits and required technology for using TNAV-equipped aircraft in the ERM environment. Author

**N86-28941#** Societe Nationale des Poudres et Explosifs, Vert-Le-Petit (France).
**NEW TRANSPARENT SOLID MATERIAL FOR HELICOPTER WINDSHIELDS Final Report [NOUVEAU MATERIAU MASSIF TRANSPARENT POUR VITRAGE D'HELICOPTERE]**
J. PATTEIN 22 Apr. 1985 37 p In FRENCH
(Contract DRET-83-129)
(SNPE-NT-37/85/CRB/NP; ESA-86-97197) Avail: NTIS HC A03/MF A01

Polyurethanes and acrylic-urethane copolymers were studied by experimental casting of large plates. Better properties are obtained by comparison to currently used acrylics, including shock resistance, crazing resistance, thermal behavior, and surface properties. Large problems remain due to mold extraction difficulties, resulting in poor surface appearance. ESA

**N86-28942#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dir. Scientifique de la Resistance des Structures.
**AEROELASTIC TESTS OF OA 206 AND OA 207 PROFILES [ESSAIS AEROELASTIQUES DES PROFILES OA 206 ET OA 207]**
B. PELEAU May 1985 73 p In FRENCH
(Contract STPA-83-95-013)
(ONERA-RT-22/1841-RY-310-R; ONERA-RT-22/1841-RY-311-G; ESA-86-97201) Avail: NTIS HC A04/MF A01

Helicopter rotor wings were tested in a wind tunnel in order to verify a semiempirical unsteady separation model. Static tests and small amplitude sine vibration tests were carried out. The OA 207 profile was also studied using large amplitude oscillations. The detailed numerical results are presented. The small amplitude data are used to establish the model while the large amplitude data are useful for its validation. ESA

**N86-28943#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
**AN INTRODUCTORY COURSE ON AIRCRAFT LOADING**
J. B. DEJONGE 1984 105 p Presented at Summer Course, Bandung, Indonesia, 1984
(NLR-MP-84090-U; B8660423; ESA-86-97506) Avail: NTIS HC A06/MF A01

Flight loads on aircraft; the effects of flexibility; and loads in continuous turbulence are introduced. Loads in steady horizontal flight; maneuver loads; gust loads; ground loads; landing loads; taxiing and handling loads; pressurization loads; and acoustic loads are discussed. ESA

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-40854*** National Aeronautics and Space Administration. Wallops Flight Center, Wallops Island, Va.
**ELIMINATION OF DIRECTIONAL WAVE SPECTRUM CONTAMINATION FROM NOISE IN ELEVATION MEASUREMENTS**
E. J. WALSH (NASA, Wallops Flight Center, Wallops Island, VA; NOAA, Propagation Laboratory, Boulder, CO), D. W. HANCOCK, III, D. E. HINES (NASA, Wallops Flight Center, Wallops Island, VA), R. N. SWIFT, and J. F. SCOTT (EG&G Washington Analytical Services Center, Inc., Pocomoke City, MD) IEEE Journal of Oceanic Engineering (ISSN 0364-9059), vol. OE-10, Oct. 1985, p. 376-381. refs

The Surface Contour Radar (SCR) is a 36-GHz computer-controlled airborne radar which generates a false-color-coded elevation map of the sea surface below the aircraft in real time, and can routinely produce ocean directional wave spectra with post-flight data processing which have much higher angular resolution than pitch-and-roll buoys. The SCR range measurements are not error-free and the resulting errors in the elevations corrupt the directional wave spectrum. This paper presents a technique for eliminating that contamination. Author

**N86-28944#** RJO Enterprises, Inc., Lanham, Md.
**AIRCRAFT AVIONICS SUITABLE FOR ADVANCED APPROACH APPLICATIONS. VOLUME 1: AIRCRAFT FLEET EQUIPAGE**
S. KOWALSKI and T. H. CROSWELL Jul. 1986 111 p
(Contract DTFA01-84-Y-01051)
(DOT/FAA/PM-86/25,1) Avail: NTIS HC A06/MF A01

This report catalogs the aircraft avionics suitable for advanced approach applications. The configuration and model numbers of avionics used in navigation and approaches for landing are provided for 79 different types of aircraft. Aircraft are grouped into five user communities which cover Major Air Carriers, Regional Air Carriers, Executive Jets, General Aviation Aircraft, and IFR Helicopters. Avionics evaluation includes VOR NAVs, ADFs, DMEs, RNAVs, AFCS, weather radar and the associated display instruments. These navigation systems are the most popular units for navigation and landing in todays aircraft. ILS glideslope receivers, marker beacon systems, navigation management systems, vertical navigation systems, and long range navigation systems are not covered. Author

**N86-28945*#** University of Southern Colorado, Pueblo. School of Applied Science and Engineering Technology.
**INVESTIGATION OF AN ADVANCED FAULT TOLERANT INTEGRATED AVIONICS SYSTEM Final Technical Report, Nov. 1983 - Mar. 1986**
W. R. DUNN, D. COTTRELL, J. FLANDERS, A. JAVORNIK, and M. RUSOVICK Mar. 1986 76 p
(Contract NCC2-277)
(NASA-CR-176980; NAS 1.26:176980) Avail: NTIS HC A05/MF A01 CSCL 01D

Presented is an advanced, fault-tolerant multiprocessor avionics architecture as could be employed in an advanced rotorcraft such as LHX. The processor structure is designed to interface with existing digital avionics systems and concepts including the Army Digital Avionics System (ADAS) cockpit/display system, navaid and communications suites, integrated sensing suite, and the Advanced Digital Optical Control System (ADOCS). The report defines mission, maintenance and safety-of-flight reliability goals as might be expected for an operational LHX aircraft. Based on use of a modular, compact (16-bit) microprocessor card family, results of a preliminary study examining simplex, dual and standby-sparing architectures is presented. Given the stated constraints, it is shown that the dual architecture is best suited to meet reliability goals with minimum hardware and software overhead. The report presents hardware and software design considerations for realizing the architecture including redundancy management requirements and techniques as well as verification and validation needs and methods. Author

**N86-29080#** Joint Publications Research Service, Arlington, Va.
**AERITALIA: AVIONICS, OPTOELECTRONICS RESEARCH, ATR 42**
A. MONDINI *In its* Europe Report: Science and Technology (JPRS-EST-86-008) p 2-5 18 Jun. 1986 Transl. into ENGLISH from Science Duemila (Rome, Italy), no. 4, Apr. 1986 p 30-33
Avail: NTIS HC A06/MF A01

The avionic systems on aircraft being designed by Aeritalia are discussed. The installation of the first European optical fiber system on board a G-22 aircraft of the Italian Air Force is planned. This experiment will be the start of a new phase of study for the installation of a complete optical fiber system on board an advanced aircraft. The Automatic Test Equipment (ATE) is explained. Also discussed is the telematic laser targeting equipment for armored vehicles. Propfan technology is examined. B.G.

# 07

# AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-40119#**
**A NEW APPROACH TO DURABILITY PREDICTION FOR FUEL TANK SKINS**
M. A. FERMAN, W. H. UNGER, C. R. SAFF (McDonnell Aircraft Co., St. Louis, MO), and M. D. RICHARDSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 102-109) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 431-437. Previously cited in issue 13, p. 1850, Accession no. A85-30331. refs

**A86-40133**
**A NEW GENERATION T56 TURBOPROP ENGINE**
W. L. MCINTIRE (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 2, no. 3, 1985, p. 189-197.

The T56 Series IV turboprop development program attempts to improve output power and specific fuel consumption (SFC) while retaining the T56 family's proven design features. Toward these ends, compressor blading efficiency has been increased by 5.6 percent, turbine efficiency has been increased by 2.0 percent, and turbine inlet temperature has been increased by 180 F, yielding a 10.5-percent reduction in SFC and a power output growth of 21 percent over the basic T56 design. Engines of Series IV type will be available in late 1986 for use in U.S. Navy E-2 aircraft, with follow-on application to U.S. Air Force C-130 and Navy P-3 aircraft. The engine will also be applicable to naval vessel propulsion. O.C.

**A86-40726**
**TURBOMACHINERY PERFORMANCE DETERIORATION; PROCEEDINGS OF THE FOURTH JOINT FLUID MECHANICS, PLASMA DYNAMICS, AND LASERS CONFERENCE, ATLANTA, GA, MAY 12-14, 1986**
W. TABAKOFF, ED. (Cincinnati, University, OH) Conference sponsored by AIAA and ASME. New York, American Society of Mechanical Engineers (Fluids Engineering Symposia Series. Volume FED-37), 1986, 162 p. For individual items see A86-40727 to A86-40740.

Various papers on engine performance deterioration and retention, turbines and compressor erosion, turbomachinery permanent and temporary performance losses, and gas and steam turbines performance deterioration are presented. The topics discussed include: compressor erosion and performance deterioration, response of an operational turbofan engine to a simulated nuclear blast, design features for performance retention in the CFM65 engine, deterioration factors in Rolls-Royce RB211 in-service performance, effect of particle characteristics on trajectories and blade impact pattern, and prediction of fouled compressor performance using stage stacking techniques. Also covered are: dilute gas-particle flow in a centrifugal compressor impeller, particle trajectories in full 3D flow field of turbomachinery, single-stage axial flow compressor performance deterioration, response of axial compressor to distorted inlet flow, clearance effects on heat transfer at the tips of plain and grooved turbine airfoils, effects of water ingestion into jet engine compressors, and liquid drop impact against a solid surface. C.D.

**A86-40727#**

### COMPRESSOR EROSION AND PERFORMANCE DETERIORATION

W. TABAKOFF (Cincinnati, University, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 1-13. refs
(Contract DAAG29-82-K-0029)

Aircraft engines operating in areas where the atmosphere is polluted by small solid particles are typical examples of jet engines operating under hostile atmospheric environment. The particles may be different kinds of sand, volcanic ashes or others. Under these conditions, the gas and particles experience different degrees of turning as they flow through the engine. This is mainly due to the difference in their inertia. This paper presents the results of an investigation of the solid particle dynamics through a helicopter engine with inlet particle separator. The particle trajectories are computed in the inlet separator which is characterized by considerable hub and tip contouring and radial variation in the swirling vane shape. The nonseparated particle trajectories are determined through the deswirling vanes and the five stage axial flow compressor. The results from this study includes the frequency of particle impacts and the erosion distribution on the blade surfaces. Author

**A86-40728#**

### RESPONSE OF AN OPERATIONAL TURBOFAN ENGINE TO A SIMULATED NUCLEAR BLAST

M. G. DUNN, C. PADOVA (Calspan Advanced Technology Center, Buffalo, NY), and R. M. ADAMS (DNA, Alexandria, VA) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 15-24. refs
(Contract DNA001-79-C-0155; DNA001-81-C-0058)

This paper describes the results of a measurement program designed to determine the transient response of an air-breathing propulsion system to simulated nuclear blast waves. A Ludwieg-tube facility, incorporating a driver technique consisting of an activating chamber and a nonfrangible diaphragm, was used to create the required shock waves. Detailed measurements were performed at incident shock overpressures of approximately 6.9, 10.3, 13.8 and 17.2 kPa (1.0, 1.5, 2.0 and 2.5 psi). For each of these overpressures, data were obtained for engine speeds of 0, 80, 90 and 100 percent of maximum speed. Typical results are presented for distortion patterns at the fan face for both an extended bellmouth and a S-shaped inlet at either 0 or 20 deg yaw angle. Author

**A86-40729#**

### DESIGN FEATURES FOR PERFORMANCE RETENTION IN THE CFM56 ENGINE

R. C. PETERSON (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 33-39.

The objective of the program described in this paper was to identify, substantiate and introduce additional design features into the CFM56 engine which will provide longer on-wing engine performance and stability margin retention considering dust ingestion effects. The initial CFM56 engine design already included many features to provide excellent retention characteristics considering other operational effects. This paper describes the initial CFM56 engine performance characteristics in DC-8 service and the design changes made to the engine which resulted in a major improvement in these characteristics. Also described is the extensive ground engine ingestion test program conducted to duplicate the initial DC-8 service results and then to evaluate and substantiate the benefits of the design improvements. Author

**A86-40730#**

### FACTORS RELATING TO DETERIORATION BASED ON ROLLS-ROYCE RB 211 IN SERVICE PERFORMANCE

J. K. CROSBY (Rolls-Royce, Ltd., Derby, England) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 41-47.

The in-service performance deterioration of an aircraft jet engine is discussed. Some aspects of the economics of deterioration are addressed, stressing the effect of deterioration on excess fuel costs. Design principles to minimize deterioration are discussed, specifying methods to handle dirt deposits, erosion, and rubbing contact. Design techniques for handling the problems caused by temperature differences are considered, especially those that affect seals. Methods of detecting deterioration are discussed, including quantifying the penalty in terms of overall engine/aircraft performance loss, usually in terms of increased fuel consumption, and identifying the components responsible for the penalty. C.D.

**A86-40731#**

### EFFECT OF PARTICLE CHARACTERISTICS ON TRAJECTORIES AND BLADE IMPACT PATTERNS

A. HAMED (Cincinnati, University, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 49-58. DOE-supported research. refs
(Contract DAAG29-82-K-0029)

This work presents the results of a detailed study of the effect of particle characteristics on the particle dynamics and on the resulting pattern of blade impacts in a two stage axial flow gas turbine operating with particle laden flows. The particle dynamics computations combine particle-blade impact characteristics, as determined from a three dimensional trajectory analysis with particle rebound characteristics, which are obtained from experimental data. The results show the pattern and blade impacts in all stationary and rotating blade rows for fly ash and for sand particles. The results demonstrate that drastically different patterns of particle blade impacts are associated with different particles. Author

**A86-40732#**

### PREDICTION OF FOULED COMPRESSOR PERFORMANCE USING STAGE STACKING TECHNIQUES

H. I. H. SARAVANAMUTTO (Carleton University, Ottawa, Canada) and A. N. LAKSHMINARASIMHA IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 59-66. NSERC-supported research. refs

The importance of compressor fouling effects on gas turbine operation is summarised. An axial multi-stage compressor performance prediction model for the simulation of the effects of fouling is described, and results for various types of fouling simulated for an actual compressor configuration are presented. Author

**A86-40735#**

### STUDY OF SINGLE STAGE AXIAL FLOW COMPRESSOR PERFORMANCE DETERIORATION

W. TABAKOFF (Cincinnati, University, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 95-100.
(Contract DAAG29-82-K-0029)

An investigation carried out on a single stage axial flow compressor to study the effect on performance deterioration of erosion due to operation in an atmosphere polluted by solid particles is reported. The experimental unit is described, including the drive unit, the test compressor, the particle feeding mechanism, and the instrumentation. The test procedure is summarized, and the results are analyzed. It is found that erosion damage can lead to significant reduction in engine efficiency and performance. The performance reduction is due mainly to changes in the blade leading and trailing edges, tip leakages, surface roughness, and pressure distribution. The data obtained from trajectory calculations are in very good agreement with the experimental findings. C.D.

**A86-40736#**

### EXPERIMENTAL AND NUMERICAL STUDY OF THE RESPONSE OF AN AXIAL COMPRESSOR TO DISTORTED INLET FLOW

G. BILLET, J. HUARD, P. CHEVALIER, and P. LAVAL (ONERA, Chatillon-sous-Bagneux, France) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 101-106. refs

A model representing the response of fixed or rotating axial compressor blade-rows is coupled to a 3-D numerical simulation of the flow outside the blade rows. The code can be used to study non-uniform compressible 3D flows through turbomachines. The fluid is assumed to be inviscid in the space outside the rows, while the viscous effects are taken into account inside. Numerical results are compared with steady distorted inflow. This comparison shows that this numerical approach is able to predict the response of the compressor. This work is part of a larger project aimed at predicting the response of a compressor to a nonuniform inlet flow that is periodic in time, or fully unsteady. Author

**A86-40737#**

### CLEARANCE EFFECTS ON HEAT TRANSFER AT THE TIPS OF PLAIN AND GROOVED TURBINE AIRFOILS

D. E. METZGER and M. K. CHYU (Arizona State University, Tempe) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 107-113. refs

Heat transfer from the hot working gases and the resulting temperature levels and gradients at the tips of axial turine blades are important factors affecting service life and possible performance deterioration in gas turbine engines. Until very recently, there was little quantitative information available on blade tip heat transfer for even simple plain flat tips and a near total absence of knowledge of the nature of the convective heat transfer mechanisms involved. The evolution of various tip geometrical treatments, such as grooving, has been based largely on trial and error rather than on an understanding of the phenomena involved. The status of present knowledge on plain tip heat transfer is discussed, and results from an experimental and numerical study of grooved tip geometries are presented. Grooving is shown to be either beneficial or detrimental from the standpoint of total tip heat transfer, depending on the groove geometry. Author

**A86-40738#**

### PERFORMANCE DETERIORATION DURING ROTATING STALL IN AXIAL COMPRESSORS

P. B. SHARMA (Indian Institute of Technology, New Delhi, India), J. W. RAILLY (Birmingham, University, England), and D. T. PAPAGEORGIOU IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 115-122. Research supported by Rolls-Royce, Ltd. refs

Experiments on three axial compressors having hub-tip ratios of 0.4, 0.66 and 0.71 are reported to illustrate the effects of various parameters such as rotor stagger, aspect ratio, hub tip ratio and the exit boundary condition on the level of pressure rise to which the compressor operation deteriorates at occurrence of rotating stall. It has been found that the pressure rise during stall varies with the above factors. The continuance of full span rotating stall to low blockage values of 6-15 percent is found to be associated with the overlap between stalled and unstalled characteristics. Hysteresis and overlap both are found to vary with hub-tip ratio and aspect ratio. Author

**A86-40739*#** Purdue Univ., West Lafayette, Ind.

### DIRECT AND SYSTEM EFFECTS OF WATER INGESTION INTO JET ENGINE COMPRESSORS

S. N. B. MURTHY, C. M. EHRESMAN, and T. HAYKIN (Purdue University, West Lafayette, IN) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 127-141. NASA-FAA-supported research. refs

Water ingestion into aircraft-installed jet engines can arise both during take-off and flight through rain storms, resulting in engine operation with nearly saturated air-water droplet mixture flow. Each of the components of the engine and the system as a whole are affected by water ingestion, aero-thermally and mechanically. The greatest effects arise probably in turbo-machinery. Experimental and model-based results (of relevance to 'immediate' aerothermal changes) in compressors have been obtained to show the effects of film formation on material surfaces, centrifugal redistribution of water droplets, and interphase heat and mass transfer. Changes in the compressor performance affect the operation of the other components including the control and hence the system. The effects on the engine as a whole are obtained through engine simulation with specified water ingestion. The interest is in thrust, specific fuel consumption, surge margin and rotational speeds. Finally two significant aspects of performance changes, scalability and controllability, are discussed in terms of characteristic scales and functional relations. Author

**A86-41549**

### SUBSTANTIATION OF REGIMES FOR ACCELERATED EQUIVALENT TESTS OF GAS-TURBINE AEROENGINES [OBOSNOVANIE REZHIMOV USKORENNYKH EKVIVALENTNYKH ISPYTANII AVIATSIONNYKH GTD]

L. P. LOZITSKII, A. N. VETROV, and V. F. LAPSHOV (Kievskii Institut Inzhenerov Grazdanskoi Aviatsii, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), April 1986, p. 73-77. In Russian. refs

After reviewing existing approaches to accelerated testing of gas-turbine aeroengines, a method is suggested for calculating equivalent accelerated test regimes. The method is based on a linear mathematical model expressing the engine's service life. The method provides simultaneous verification of service life for some structural engine elements. It is used to calculate the regimes for testing the service times of the turbine blade, the rotor bearing, and the compressor blade. It is also used to calculate the resonance regimes involving tests of the engine's dynamic durability. I.S.

**A86-41691#**

### EFFECT OF ENGINE TECHNOLOGY ON ADVANCED FIGHTER DESIGN AND COST

O. HERRMANN and W. BIEHL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 137-143) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 472-476. Previously cited in issue 22, p. 3192, Accession no. A84-44943. refs

**A86-41708*#**

### FLIGHT EFFECTS ON NOISE FROM COAXIAL DUAL FLOW. II - HEATED JETS

R. DASH (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 940-947. refs (Contract NCC2-75)

This paper is a continuation of the study described in Part I and deals with the flight effects on noise from heated jets. The present work shows that coaxial exhaust flows with inverted profiles are much quieter than flows with conventional profiles. Among all possible coaxial configurations with only one of the streams heated conventional profile, inverted profile, and the variable stream control engine (VSCE) cycle - and holding constant mass flow and thrust, a VSCE cycle is the best possible engine cycle as it provides over 18-dB reduction in sound pressure level (as compared to noise from a conventional profile cycle) at all angles, both statically and in flight. The study also indicates that, if both the coaxial streams are heated unequally, a duct-burning profile, combined with the variable stream control engine (DB-VSCE) concept, gives rise to a powerful coaxial device which generates the least noise, both statically and in flight. This concept will be of paramount importance as one of the most variable nozzle designs of the future. Author

**A86-41726*#** Texas A&M Univ., College Station.

**NUMERICAL EVALUATION OF PROPELLER NOISE INCLUDING NONLINEAR EFFECTS**

K. D. KORKAN, E. VON LAVANTE (Texas A&M University, College Station), and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 1043-1045. refs

(Contract NAG3-354)

Propeller noise in the acoustic near field is presently determined through the integration of the pressure-time history in the tangential direction of a numerically generated flowfield around a propfan of SR-3 type, including the shock wave system in the vicinity of the propeller tip. This acoustic analysis yields overall sound pressure levels, and the associated frequency spectra, as a function of observer location. O.C.

**A86-42099**

**AFTER THE BIG TURBOFANS**

J. MOXON Flight International (ISSN 0015-3710), vol. 129, May 24, 1986, p. 32, 34.

An evaluation is made of the configurational features and prospective performance gains of next-generation airliner engines that attempt to reduce specific fuel consumption below the state-of-the-art values for large turbofan engines. Attention is given to 60,000-lb thrust class engine concepts that maximize airflow bypass; these encompass an Advanced Ducted Propeller configuration, employing a gearbox and variable pitch blades that are enclosed in a conventional nacelle, the 'Contra Fan', which is an ungeared contrarotating ducted fan, and the contrarotating Unducted Fan. O.C.

**A86-42425#**

**DEVELOPMENT OF 'CADEGA' CAD SYSTEM FOR AERO ENGINE DESIGN**

I. KATSUMATA, T. FURUHASHI, J. TAKANO, Y. ISHIKAWA, and T. TAKAHASHI Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 26, March 1986, p. 136-140. In Japanese, with abstract in English.

This paper introduces the CADEGA (Computer Aided Design for Engine General Arrangement) system which is instrumental in aero engine development. Questions were addressed with regard to what CAD can do for engine design, how to introduce CAD, how to implement a new CAD system, and problems related to the present design. Some of the computer programs which have been developed to make this CAD system more effective are explained in detail. This CADEGA system consists of a stacking program which can automatically produce drawings of general engine arrangements through stacking instruction using the CAD data base called master profiles. CADEGA is fully applied to the V2500 Engine design and all the detailed design information is exchanged among parties (five nations in international collaboration) using the CAD data given from this system. Author

**A86-42657#**

**AIR TURBINE TEST RESULTS FOR THREE TURBINE STAGES WITH VARYING RADIAL DISTRIBUTION OF CAMBER**

T. C. FLAHERTY and A. C. GOMINHO (General Electric Co., Aircraft Engine Business Group, Lynn, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.

(AIAA PAPER 86-1467)

Three high pressure ratio turbine stages were designed and tested, having different radial distributions of blading camber in both stator and rotor. The three turbines were designed to the same thermodynamic conditions, with radial distribution of throat area being given three variations: (1) approximately linear ('conventional' design); (2) open at mid-span and closed at hub and tip relative to conventional ('over-cambered'); and (3) closed at mid-span and opened at hub and tip ('de-cambered'). In order to make the radial camber distribution the only variable in the test series, axial width of the blading was varied radially so that all three designs would have the same radial distribution of Zweifel coefficient. The turbines were tested in a warm air facility with conventional fixed instrumentation and with traversing of the exit annulus by a five-hole probe. The over-cambered and de-cambered designs had lower efficiency than the conventional design. Stage exit survey results are presented as well as overall efficiency comparisons. The exit survey results include radial velocity components, and are presented in contour plots as well as radial plots of average quantities. Author

**A86-42659#**

**COUNTER-ROTATION PROP-FAN OPTIMIZATION**

R. E. OWENS, W. W. FERGUSON (United Technologies Corp., Engineering Div. East Hartford, CT), and D. M. MABEE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 13 p. refs

(AIAA PAPER 86-1470)

An analytical study was conducted to find the best counter-rotation Prop-Fan to power a 120-passenger transport aircraft with aft-mounted engines. Figures-of-merit used in this study were fuel burn, direct operating cost, and noise. Propfan variables studied were number of blades, tip speed, diameter, and activity factor. The effects of these parameters on the performance, weight, and cost of the Prop-Fan were estimated. These estimates were then used to determine propulsion system (including gearbox, engine, nacelle, and pylon) weight, cost, and performance. Influence coefficients were used to determine the effect of these on airplane fuel burn and direct operating cost. The effects of Prop-Fan diameter and weight on airplane configuration and tail size were also included in this analysis. A matrix of 144 Prop-Fans was evaluated in this manner. A number of specific cases were chosen from this matrix for FAR 36 far field (community) and near field (cabin) noise evaluation. Author

**A86-42660#**

**TURBOPROP AND OPEN ROTOR PROPULSION FOR THE FUTURE**

J. H. R. SADLER (Rolls-Royce, Ltd., Derby, England) and G. S. HODGES (Rolls-Royce, Ltd., Bristol, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.

(AIAA PAPER 86-1472)

The factors which influence operating cost of turboprop and open rotor propulsors are shown to vary with the engine application, leading to different optimum design solutions for different aircraft. Generalised relationships between turboprop aircraft design range, power requirements and operating costs breakdown are drawn, showing their influence on both thermodynamic cycle selection and individual component design. The changing effects of physical size on engine layout are also considered, together with the constraints of different engine installations. Conclusions are related to actual design exercises carried out for engines with power outputs ranging from 2000 to 12000 shp. Author

**A86-42662#**

**TURBOFAN AND PROPFAN AS BASIS FOR FUTURE ECONOMIC PROPULSION CONCEPTS**

H. GRIEB and D. ECKARDT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 13 p.

(AIAA PAPER 86-1474)

While such advanced airliner powerplant configurations as the counterrotating propfan promise considerable reductions in fuel consumption, their integration into aircraft poses design configuration problems requiring a fundamental reorientation. It is noted that the noise from single and counterrotation propfans leads to cabin noise level increases in wing-mounted engine configurations, as well as to structural problems involving center of gravity and maneuverability in the case of tail-mounted engines (which are more suitable with respect to cabin noise). Attention is presently given to a counterrotating shrouded fan, which synthesizes the advantages of turbofan and propfan engines to yield a configurationally optimal design. O.C.

**A86-42672#**

**TURBINE AIRFOIL LCF LIFE PREDICTION VERIFICATION**

F. O. SOECHTING (United Technologies Corp., Engineering Div., West Palm Beach, FL) and R. J. ALLEN (USAF, Wright Aeronautical Laboratory, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1496)

An improved turbine airfoil low cycle fatigue (LCF) life prediction model is evaluated. Core engine tests were conducted in a LCF test facility to provide complete characterization of steady-state and transient environments. The procedure for verifying the airfoil metal temperature distribution predictions on a turbine airfoil are described; the internal and external heat transfer features are examined. The cooling design for the blade is discussed. The distribution of film effectiveness on the airfoil surface is predicted. The relation between the external heat transfer coefficient and the distribution of adiabatic wall temperature is analyzed. The airfoil metal temperature for thermal fatigue life predictions is verified. The LCF model considers the temperature and stress or strain range by utilizing thermal-mechanical fatigue test data for the super-alloys. It is noted that the LCF life mode and heat transfer model provide accurate prediction of the location of turbine airfoil crack initiation and a good estimate of LCF capability. I.F.

**A86-42694#**

**ALTITUDE IGNITION/LEAN DECELERATION STUDY**

J. R. TAYLOR and S. K. WIDENER (General Electric Co., Evendale, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1530)

Combustor lean ignition and flame stability limits are prime considerations in the design of advanced turbine engines. The physical processes governing ignition and blowout are well understood qualitatively, but are not easily modeled or predicted. This paper presents ignition and blowout correlations for seven General Electric combustor designs. The purely empirical relations illustrate the lack of consistent trends from one design to the next; the influence of operating parameters cannot be generalized using current information. The empirical approach presented here is useful for analyzing performance of a given combustor design and provides important information regarding trends with operating variables. Author

**A86-42698#**

**DEVELOPMENT OF THE BOEING 767 THRUST REVERSER**

J. JACKSON (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1536)

The Boeing 767 is a twin engine wide bodied commercial airplane powered by either Pratt and Whitney JT9D, or General Electric CF6 turbofan engines. This paper describes the development of the Boeing thrust reverser for the 767 airplane from configuration development to FAA certification. Unless otherwise stated the contents of this paper apply to both JT9D and CF6 installations. The requirements of the thrust reverser, together with details of each phase of development in meeting the requirements are presented. Particular attention is directed at Boeing's first use of Turbo Powered Simulator nacelles for wind tunnel thrust reverser model testing and the advantage of this technique over more conventional blowing nacelle models. Finally, in-service experience and reliability together with resolutions of associated problems are discussed. Author

**A86-42701*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DYNAMIC PRESSURE LOADS ASSOCIATED WITH TWIN SUPERSONIC PLUME RESONANCE**

J. M. SEINER, J. C. MANNING (NASA, Langley Research Center, Hampton, VA), and M. K. PONTON (PRC Kentron International, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1539)

The phenomenon of twin supersonic plume resonance is defined and studied as it pertains to high level dynamic loads in the inter-nozzle region of aircraft like the F-15 and B1-A. Using a 1/40th scale model twin jet nacelle with powered choked nozzles, it is found that intense internozzle dynamic pressures are associated with the synchrophased coupling of each plume's jet flapping mode. This condition is found most prevalent when each plume's jet flapping mode has constituent elements composed of the B-type helical instability. Suppression of these fatigue bearing loads was accomplished by simple geometric modifications to only one plume's nozzle. These modifications disrupt the natural selection of the B-type mode and thereby decouple the plumes. Author

**A86-42702*#** General Motors Corp., Indianapolis, Ind.

**ROTORCRAFT PROPULSION FOR YEAR 2000 PLUS**

T. R. LARKIN, D. V. STATON, and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p. Army-supported research.
(Contract NAS3-24542)
(AIAA PAPER 86-1543)

The objective of this study was to identify high-payoff technologies for year 2000 small gas turbine engines for rotorcraft application. A current state-of-the-art technology Allison gas turbine engine was used as a baseline and three advanced concepts were studied: the simple cycle engine, a waste heat recovery cycle, and a wave rotor engine cycle. For the simple cycle engine, two general arrangements were considered: the traditional concentric spool arrangement and a nonconcentric spool arrangement. Both a regenerative and a recuperative cycle were studied for the waste heat recovery cycle. An extensive cycle optimization procedure was performed for each configuration under study using relative direct operating cost (DOC) as the figure of merit. A high pressure ratio nonconcentric engine provided the greatest reduction in DOC with a 16.5 percent improvement. Author

**A86-42703*#** Avco Lycoming Div., Stratford, Conn.

**SMALL ENGINE TECHNOLOGY PAYOFFS FOR FUTURE COMMUTER AIRCRAFT**

H. KAEHLER and W. SCHNEIDER (Avco Lycoming Textron, Stratford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Army-supported research.
(Contract NAS3-24545)
(AIAA PAPER 86-1544)

High payoff technologies for a year 2000 regenerative cycle turboprop engine were identified for a 19 passenger commuter aircraft application. A series of engines incorporating eight levels of advanced technologies were studied and their impact on aircraft performance was evaluated. Four advanced technologies are recommended to achieve a potential reduction in fuel burn of 38.3 percent. At $1.00 per gallon fuel price, a potential direct operating cost (DOC) benefit of 12.5 percent is obtained. At $2.00 per gallon, the potential DOC benefit increases to 17.0 percent. Author

**A86-42708#**

### A REPORT ON THE INITIAL TESTING OF THE LARGE SCALE ADVANCED PROP-FAN

C. L. DEGEORGE, J. E. TURNBERG, and H. S. WAINAUSKI (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p.
(AIAA PAPER 86-1551)

It is pointed out that the Large Scale Advanced Prop-Fan (LAP) represents the culmination of over ten years of effort to extend the operating envelope of the propeller from the .6 Mn levels attained by contemporary turboprop powered aircraft to the .8 Mn speeds of today's turbofan powered commercial airliners. The efficiency of the Prop-Fan should make it possible to design aircraft which are 15 percent to 25 percent more efficient than today's technologically most advanced turbofan powered airliners. A report is presented regarding the initial testing conducted under the LAP program. Attention is given to a description of the LAP, the instrumentation system, aspects of whirl rig testing, and the static rotor test. No barriers were discovered which would prevent a continuation of the studies with wind tunnel, engine, and flight test programs in 1986 and 1987. G.R.

**A86-42710#**

### HIGH PERFORMANCE, STRATIFIED CHARGE ROTARY ENGINES FOR GENERAL AVIATION

R. E. MOUNT (John Deere Technologies International, Inc., Rotary Engine Div., Wood Ridge, NJ) and W. L. GREINER (Avco Lycoming Textron, Williamsport, PA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. refs
(AIAA PAPER 86-1553)

This paper discusses the application of advanced and highly advanced technologies to the direct injected, liquid cooled, Jet-A fueled, Stratified Charge Rotary Engine for high specific output, advanced and highly advanced general aviation engines. Author

**A86-42737*#** Science Applications International Corp., Princeton, N.J.

### COMPUTATIONAL MODELS FOR THE ANALYSIS/DESIGN OF HYPERSONIC SCRAMJET COMPONENTS. I - COMBUSTOR AND NOZZLE MODELS

S. M. DASH, N. SINHA, D. E. WOLF, and B. J. YORK (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 20 p. refs
(Contract NAS1-16535)
(AIAA PAPER 86-1595)

An overview of computational models developed for the complete, design-oriented analysis of a scramjet propulsion system is provided. The modular approach taken involves the use of different PNS models to analyze the individual propulsion system components. The external compression and internal inlet flowfields are analyzed by the SCRAMP and SCRINT components discussed in Part II of this paper. The combustor is analyzed by the SCORCH code which is based upon SPLITP PNS pressure-split methodology formulated by Dash and Sinha. The nozzle is analyzed by the SCHNOZ code which is based upon SCIPVIS PNS shock-capturing methodology formulated by Dash and Wolf. The current status of these models, previous developments leading to this status, and, progress towards future hybrid and 3D versions are discussed in this paper. Author

**A86-42751#**

### A NOZZLE DESIGN ANALYSIS TECHNIQUE

J. J. BROWN (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1613)

A method for calculating the flowfield in propulsive nozzles is presented. The complete set of partial differential equations for time-dependent, compressible, viscous flow is solved using an efficient numerical procedure. The flowfield is subdivided into rectangular regions called cells. The fluxes of conserved properties (mass, momentum, and energy) into each cell are balanced using a finite-volume approach. Solid boundary conditions are enforced using an imaginary row of cells inside the body. The inflow and outflow boundary conditions are enforced using a method of characteristics formulation. The method uses the line Gauss-Seidel implicit technique of MacCormack to solve the Reynolds-averaged Navier-Stokes equations in the computational domain. The Baldwin-Lomax algebraic turbulence model is used to include the subgrid effects of turbulence. Multistream, axisymmetric nozzle flowfields, including mixing of the streams, can be analyzed using this method. A fan nozzle thrust reverser can be analyzed as well. Results are presented for a converging-diverging propulsive nozzle, a three-stream turbofan nozzle, and a turbofan nozzle with thrust reverser. The computational results show excellent agreement with the experimental data. A two-order of magnitude reduction in run cost relative to the MacCormack explicit method is demonstrated. Author

**A86-42755*#** Purdue Univ., West Lafayette, Ind.

### TRANSIENT ENGINE PERFORMANCE WITH WATER INGESTION

T. HAYKIN and S. N. B. MURTHY (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 21 p. refs
(Contract NAG3-481)
(AIAA PAPER 86-1621)

The immediate effects on the transient performance of a generic, high bypass ratio jet engine on account of water ingestion are discussed. The air compression subsystem has been analyzed with respect to four aerothermodynamic and mechanical processes associated with two-phase fluid flow and the engine simulation has been carried out under three limiting cases of interest in practice, one pertaining to draining of water at the end of compression and the other two, to partial evaporation at two different locations in the burner. General observations are made on engine operability as a function of engine and control design under various engine and (control input) sensor operating conditions, with various mass fractions of water in the air-water mixture entering the engine, during various pilot-initiated power demand changes. Author

**A86-42757#**

### SMALL TURBOSHAFT/TURBOPROP ENGINE TECHNOLOGY STUDY

R. HIRSCHKRON and C. J. RUSSO (General Electric Co., Lynn, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p.
(AIAA PAPER 86-1623)

A study was conducted on turboshaft/turboprop engines in a nominal 850 shp size to determine advanced technology payoff in typical aircraft missions. Payoff was evaluated vs a reference engine based on current technology. The results indicate worthwhile areas of development in compressor and turbine aerodynamic viscous codes, ceramic composite materials, and advanced ceramic recuperators. An advanced simple cycle engine could demonstrate a 20 percent fuel saving and a 24 percent life cycle cost (LCC) reduction vs current engines. An advanced recuperative engine increases the fuel reduction potential to 37 percent, but with a smaller LCC improvement. An engine incorporating far term, post year 2000 technologies could reach fuel savings reductions of 50 percent. Author

**A86-42758#**

### SMALL ENGINE PROPULSION READINESS FOR THE 21ST CENTURY

J. A. ALCORTA (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1624)

Attention is given to advanced component technologies that can impart significant performance improvements to small turbine engines, such as may be applied to land vehicles, cruise missiles, helicopters, private aircraft and auxiliary power units. These technologies, which encompass modified compressor blading, ceramic combustors, actively cooled radial inflow turbines, advanced Ti alloys, intermetallic materials, and improved bearings, can when integrated yield 20-30 percent reductions in fuel consumption while improving specific power by 50 percent over current comparable engines. O.C.

**A86-42759#**

### PROPFAN TEST ASSESSMENT (PTA) QUICK ENGINE CHANGE (QEC) NACELLE

T. BRADLAUGH-DREDGE (Rohr Industries, Inc., Chula Vista, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p.
(AIAA PAPER 86-1626)

A flightworthy Quick Engine Change (QEC) nacelle consisting of upper, lower inlet nose and side cowl composite components mating with internal aluminum frames of steel V braces developed for NASA's Propfan Test Assessment (PTA) program. Loads imposed by the propfan, gearbox and power section of the drive system are transmitted through the gearbox mounts to the forward metallic frames and intercostals, and are then carried aft to the airframe interface through the upper and lower composite cowl panels and via the metallic V brace assemblies. P-3 common hardware was used whenever possible, and design considerations led to the evolution of a hybrid structure design combining external graphite epoxy composite cowling with P-3 common conventional metallic internal structure. Structural design analysis substantiation and critical structural element static and fatigue composite subelement tests were performed. R.R.

**A86-42784#**

### DESIGN FOR ENGINE SUPPORTABILITY

F. C. GILLETTE, T. J. CHRISTIE, W. H. QUIGLEY, and J. M. SHIPMAN (United Technologies Corp., Engineering Div., West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1671)

Advanced weapon systems require greatly improved supportability to provide the levels of availability and readiness required to counter the emerging threat. This paper addresses a new design approach which has been implemented to ensure supportability. Supportability must be addressed early in the development cycle when it is most cost-effective to implement. The key elements of this new approach are a designer 'awareness' program, supportability reviews, comprehensive trade studies, early support tool involvement, and a full-scale engine mockup built early in the program. These changes in the design process have provided designers with an awareness of current engine maintenance and support concerns. Moreover, it has instilled a disciplined approach to resolve these issues on the next-generation fighter engine. The paper concludes with a discussion of how this new design approach benefits the user and the weapon system. Author

**A86-42786#**

### A FAULT-TOLERANT 1750A ENGINE CONTROLLER

S. NELSON, W. STANTON, and J. VOLP (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1675)

Jet engine control is in a state of transition from traditional passive, hydro-mechanical to electronic. While actuation will remain hydro-mechanical, next generation engine controllers will most certainly be electronic and fault tolerant. This paper develops the rationale for fault-tolerant engine controllers. System trade-offs necessary to determine the appropriate level of redundancy are described, various fault-tolerant computer architectures are compared, and a 1750A fault-tolerant computer that was developed as a prototype for next generation engine control along with some of the lessons learned from that project are described. Author

**A86-42787*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

### TEST AND EVALUATION OF THE HIDEC ENGINE UPTRIM ALGORITHM

R. J. RAY and L. P. MYERS (NASA, Flight Research Center, Edwards, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1676)

The highly integrated digital electronic control (HIDEC) program will demonstrate and evaluate the improvements in performance and mission effectiveness that result from integrated engine-airframe control systems. Performance improvements will result from an adaptive engine stall margin mode, a highly integrated mode that uses the airplane flight conditions and the resulting inlet distortion to continuously compute engine stall margin. When there is excessive stall margin, the engine is uptrimmed for more thrust by increasing engine pressure ratio (EPR). The EPR uptrim logic has been evaluated and implemente into computer simulations. Thrust improvements over 10 percent are predicted for subsonic flight conditions. The EPR uptrim was successfully demonstrated during engine ground tests. Test results verify model predictions at the conditions tested. Author

**A86-42788#**

### ADVANCES IN AERO ENGINE DYNAMICS

J. B. WYNNE (Rolls-Royce, Ltd., Filton, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Research supported by the Ministry of Defence (Procurement Executive).
(AIAA PAPER 86-1677)

An account is given of state-of-the-art methods for aircraft turbine engine dynamic balancing at the design and design-verification stages; these are based on FEMs, in the case of engine models, and finite difference time-stepping, in the case of dynamic response prediction. Attention is given to the effects of such operational circumstances as the loss of blading through foreign object ingestion, the characteristics of squeeze film bearings, and the measurement and monitoring of engine vibration. The function of alarm levels, bearing alignment principles, and diagnostic methods are discussed. O.C.

**A86-42789#**

### KNOWLEDGE-BASED SYSTEMS FOR ROTORDYNAMIC DIAGNOSTICS

B. B. AGGARWAL, J. C. GIORDANO (Mechanical Technology, Inc., Latham, NY), and S. J. PRZYBYLKO (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(Contract F33615-85-C-2513)
(AIAA PAPER 86-1678)

The knowledge-based systems considered differ from traditional systems in that the knowledge base is separate from the decision-making logic of the program. Such a separation makes it possible to handle problems of much larger scope and complexity. The investigation described represents the first step in an effort concerned with the application of this technology to the turbine engine domain. Attention is given to gas turbine engine rotor diagnostics, the demonstration of a knowledge-based diagnostic system, a rotordynamic test rig, aspects of data acquisition, and a knowledge-based rotor diagnostic system. The detection of faults implanted in a laboratory test rig provided a successful demonstration of a knowledge-based rotordynamic diagnostic system. G.R.

**A86-42790#**

**AN OVERVIEW OF USAF ENGINE DIAGNOSTIC SYSTEMS**

S. J. THORNTON (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(AIAA PAPER 86-1679)

A development history is presented for the U.S. Air Force's engine diagnostic systems, with attention to the automation of diagnostics first introduced in the F100 turbofan engine's Events History Recorder. Other efforts have involved the T-38 trainer's J85 turbojet Engine Health Monitoring System, the A-10 ground support aircraft's TF34 turbofan Turbine Engine Monitoring System, and the F-15 fighter's F100 turbofan Engine Diagnostics System. State-of-the-art systems are currently installed in the KC-135, B-1B, and F-16 aircraft. The Integrated Turbine Engine Monitoring System and Joint Advanced Fighter Engine diagnostic system (for the Advanced Tactical Aircraft), which are undergoing development are also discussed. O.C.

**A86-42792#**

**SOLID FUEL GAS GENERATOR AIR**

W. C. CALVO, K. L. CHRISTENSEN, and M. H. FEDUN (Aerojet TechSystems Co., Sacramento, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 5 p.

(AIAA PAPER 86-1682)

This paper describes: (1) the Air TurboRamjet (ATR) engine cycle when using a Solid Fuel Gas Generator (SFGG) to drive the turbocompressor, (2) the computer codes that are used to establish the engine mechanical design and predict the design and off-design performance, and (3) a test bed ATR engine that will be tested in the near future to demonstrate the engine and the SFGG cycle. Author

**A86-42818#**

**ADVANCED TURBINE ENGINE SIMULATION TECHNIQUE DEVELOPMENT AND APPLICATIONS TO TESTING**

M. A. CHAPPELL (Sverdrup Technology, Inc., Arnold Air Force Station, TN) and E. G. BLEVINS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. USAF-sponsored research. refs

(AIAA PAPER 86-1731)

The Advanced Turbine Engine Simulation Technique (ATEST) is digital computer simulation system for the prediction and correlation of both steady-state and transient engine performance. ATEST has been developed using both a modular concept which provides the flexibility to simulate arbitrary engine cycle configurations and a modified Newton-Raphson numerical method (matrix solver) to achieve convergence at both design and off-design operating points. In addition, ATEST has the capability to treat the specialized characteristics of a particular engine (turbine cooling air paths, Reynolds number effects, etc.) to the degree of detail required by the user. The technique has been developed around a collection of the best features of current advanced engine simulations used in government and industry. ATEST is intended for aircraft gas turbine engine cycles (e.g., single-spool turbojet, high-bypass turbofan, variable-cycle engine, etc.) but could also be used to simulate other physical systems, taking advantage of the modular structure. The ATEST has been successfully applied to a number of different turbine engine cycles. These cycles represent a wide spectrum of the different types of aircraft gas turbine engines and include a single-spool turbojet (J79), a dual-spool turbojet (J57), dual-spool mixed-flow turbofans (F100, F110, F109, F404), a dual-spool separate-flow turbofan (CFM56), a turboshaft engine (T64), and an unconventional cycle engine. The ATEST has been written in FORTRAN 77 and has been executed on a variety of digital computers, including the AMDAHL 5860, CRAY-XMP, and CYBER 7600. Author

**A86-42823#**

**IMPROVED COMPRESSOR PERFORMANCE USING RECESSED CLEARANCE (TRENCHES) OVER THE ROTOR**

D. C. WISLER and B. F. BEACHER (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs

(Contract F33615-81-C-2030)

(AIAA PAPER 86-1745)

A systematic investigation of the effects on compressor performance of recessing (trenching) the case over the rotor tips was conducted in a four-stage research compressor. Variations in the slope of the trench, the depth of the trench, rotor tip penetration into the trench, distances of start and termination of the trench relative to the blade edges, and rotor tip clearances were evaluated. The effects of each geometric parmeter upon compressor efficiency and stall margin were determined. An innovative sloped trench configuration was developed and found to be superior to any other trench configuration tested, giving in one case a 0.5 point improvement in efficiency without adversely affecting stall margin. Author

**A86-42826#**

**USING DERIVATIVE ENGINE TECHNOLOGY TO ACHIEVE MATURITY GOALS**

R. P. TAYLOR, F. BYRD, and E. A. YOUNG (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs

(AIAA PAPER 86-1752)

The use of 'Derivative' aircraft turbine engines is proving to be a surer, faster way of achieving the early engine maturity goals desired by engine producers and engine users alike. In addition, advanced Derivatives offer fuel burn reductions comparable to 'new' engines. In fact, only giant steps in engine technology can provide a significant improvement over today's mature Derivative engines. Author

**A86-42830#**

**PERFORMANCE ESTIMATION OF THE MIXED FLOW, AFTERBURNING, COOLED, TWO-SPOOL TURBOFAN ENGINE WITH BLEED AND POWER EXTRACTION**

J. D. MATTINGLY, W. H. HEISER (U.S. Air Force Academy, Colorado Springs, CO), and D. H. DALEY AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 29 p.

(AIAA PAPER 86-1757)

This paper develops a model of the mixed flow, afterburning turbofan engine used for preliminary engine cycle analysis and selection in the Propulsion Design course at the United States Air Force Academy and in the upcoming AIAA Education Series textbook Aircraft Engine Design. The simplified model of this complex engine cycle, while retaining the major engine design variables and predicting the engine off-design performance over a wide range of flight conditions and throttle settings, is understandable by senior engineering design students. A user friendly micro-computer program of the engine model has been developed and typical results are presented. Author

**A86-43381**

**CALCULATION OF THE CHARACTERISTICS OF A MULTISTAGE GAS TURBINE WITH ALLOWANCE FOR THE CIRCUMFERENTIAL NONUNIFORMITY OF INLET TEMPERATURE [RASCHET KHARAKTERISTIK MNOGOSTUPENCHATOI GAZOVOI TURBINY S UCHETOM OKRUZHNOI NERAVNOMERNOSTI TEMPERATURY NA VKHODE]**

V. IU. DOZORNOV, R. A. KILDEEV, and A. P. TUNAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 22-25. In Russian.

A program (GROT) is described which makes it possible to calculate the performance characteristics of a multistage turbine with a nonuniform inlet-temperature field. Results are presented for the single-stage turbine of a high-pressure turbofan engine. B.J.

**A86-43383**

**GENERALIZATION OF EXPERIMENTAL DATA ON THE INTERNAL HYDRAULIC RESISTANCE OF LAMINATED POROUS MATERIALS [OBOBSHCHENIE OPYTNYKH DANNYKH PO VNUTRENNIM GIDRAVLICHESKIM SOPROTIVLENIIAM PRONITSAEMYKH VAFEL'NYKH MATERIALOV]**

V. I. LOKAI and A. V. SHCHUKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 30-34. In Russian. refs

The paper considers the generalization of experimental data on laminated porous materials, used in cooling the components of high-temperature gas turbine engines. This generalization has the form of the dependence of the internal hydraulic resistance of the materials on the Reynolds number of the coolant flow. B.J.

**A86-43390**

**THE DEVELOPMENT OF A MODEL FOR THE UNSTABLE OPERATION OF A TURBOCOMPRESSOR AND THE DESIGN OF A DEVICE TO PROTECT A GAS TURBINE ENGINE AGAINST STALLING AND SURGING [RAZRABOTKA MODELI NEUSTOICHIVOI RABOTY TURBOKOMPRESSORA I POSTROENIE USTROISTVA DLIA ZASHCHITY GTD OT POMPAZHA]**

M. M. SHAKIRIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 61-66. In Russian. refs

Changes in the operation of a turbocompressor during stalling and surging of the gas turbine engine are examined. A device has been developed which eliminates stalling-and-surging phenomena by acting on three control units of the powerplant. B.J.

**A86-43393**

**MODELING THE COMBUSTION ZONE OF GAS-TURBINE-ENGINE COMBUSTION CHAMBERS [MODELIROVANIE ZONY GORENIIA KAMER SGORANIIA GTD]**

V. M. IANKOVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 73-76. In Russian. refs

A physical model of the combustion zone of a combustor with a 'closed' front unit is developed on the basis of an investigation of the jet-interaction region of the first band of apertures of the flame tube. A mathematical interpretation is given of the model, which consists of three interacting reactors. Numerical results are presented, and a comparison with experimental data confirms the adequacy of the model to the actual combustion process. B.J.

**A86-43395**

**SMALL FILM-EVAPORATION TYPE COMBUSTION CHAMBER FOR A LOW-POWER GAS TURBINE ENGINE [MALORAZMERNAIA PLENOCHNO-ISPARITEL'NAIA KAMEKA SGORANIIA GTD MALOI MOSHCHOSTI]**

V. N. AFROSIMOVA, E. I. KOZELSKII, and S. A. VOLOSHIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 82-85. In Russian. refs

Film-evaporation mixing schemes are used in the design of low-toxicity combustion chambers. In the present paper, experimental results are given concerning the effectiveness of using a film-evaporation type combustion chamber in a low-power (10-20 kW) gas turbine engine with rigorous size limitations. The presence of an evaporator in the chamber makes possible a maximum reduction in the size of the combustion zone. The relative flowrate of the primary air is determined at which mixture combustion with high efficiency (not less than 99 percent) is achieved without leaving a residue in the chamber. B.J.

**N86-28085*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**UNIFORM ENGINE TESTING PROGRAM PHASE 7: NASA LEWIS RESEARCH CENTER SECOND ENTRY**

T. J. BIESIADNY, L. A. BURKARDT, M. ABDELWAHAB, W. M. BRAITHWAITE, T. A. KIRCHGESSNER, and D. SILVER Jul. 1986 69 p

(NASA-TM-87272; E-2971; NAS 1.15:87272) Avail: NTIS HC A04/MF A01 CSCL 21E

The propulsion and Energetics Panel, Working Group 15, of the Advisory Group for Aerospace Research and Development (AGARD) is sponsoring a Uniform Engine Testing Program (UETP). In this program, two jet engines were tested under identical conditions in certain NATO altitude and ground-level facilities as a means of correlating these facilities. With this second entry, NASA documented engine deterioration that may have occurred since inception of the UETP. Additionally, NASA investigated anomalies discovered during review of data from the five facilities which had participated in the program between the two NASA entries. Author

**N86-28088*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**TEST AND EVALUATION OF THE HIDEC ENGINE UPTRIM ALGORITHM**

R. J. RAY and L. P. MYERS Jul. 1986 13 p Presented at the AIAA/ASME/SAE/ASEE 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986

(NASA-TM-88262; H-1363; NAS 1.15:88262) Avail: NTIS HC A02/MF A01 CSCL 21E

The highly integrated digital electronic control (HIDEC) program will demonstrate and evaluate the improvements in performance and mission effectiveness that result from integrated engine-airframe control systems. Performance improvements will result from an adaptive engine stall margin mode, a highly integrated mode that uses the airplane flight conditions and the resulting inlet distortion to continuously compute engine stall margin. When there is excessive stall margin, the engine is uptrimmed for more thrust by increasing engine pressure ratio (EPR). The EPR uptrim logic has been evaluated and implemented into computer simulations. Thrust improvements over 10 percent are predicted for subsonic flight conditions. The EPR uptrim was successfully demonstrated during engine ground tests. Test results verify model predictions at the conditions tested. Author

**N86-28946*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

**A SUPERSONIC FAN EQUIPPED VARIABLE CYCLE ENGINE FOR A MACH 2.7 SUPERSONIC TRANSPORT Final Report**

T. S. TAVARES 22 Aug. 1985 107 p

(Contract NAG3-697)

(NASA-CR-177141; NAS 1.26:177141) Avail: NTIS HC A06/MF A01 CSCL 21E

The concept of a variable cycle turbofan engine with an axially supersonic fan stage as powerplant for a Mach 2.7 supersonic transport was evaluated. Quantitative cycle analysis was used to assess the effects of the fan inlet and blading efficiencies on engine performance. Thrust levels predicted by cycle analysis are shown to match the thrust requirements of a representative aircraft. Fan inlet geometry is discussed and it is shown that a fixed geometry conical spike will provide sufficient airflow throughout the operating regime. The supersonic fan considered consists of a single stage comprising a rotor and stator. The concept is similar in principle to a supersonic compressor, but differs by having a stator which removes swirl from the flow without producing a net rise in static pressure. Operating conditions peculiar to the axially supersonic fan are discussed. Geometry of rotor and stator cascades are presented which utilize a supersonic vortex flow distribution. Results of a 2-D CFD flow analysis of these cascades are presented. A simple estimate of passage losses was made using empirical methods. Author

**N86-28947*#** Teledyne CAE, Toledo, Ohio.
**VARIABLE AREA RADIAL TURBINE FABRICATION AND TEST PROGRAM**
C. ROGO Aug. 1986 91 p
(Contract NAS3-23173; DA PROJ. 1L1-61101-AH-45)
(NASA-CR-175091; NAS 1.26:175091; AVSCOM-TR-86-C-13)
Avail: NTIS HC A05/MF A01 CSCL 21E

A variable area radial turbine with a moveable nozzle sidewall was experimentally evaluated. The turbine was designed for an advanced variable capacity gas turbine rotorcraft engine. The turbine has a mass flow rate of 2.27 kg/sec (5.0 lbs/sec), and a rotor inlet temperature of 1477K (2200 F). Testing was conducted at a reduced inlet temperature, but the aerodynamic parameters and Reynolds numbers were duplicated. Overall performance was obtained for a range of nozzle areas from 50% to 100% of the maximum area. The test program determined the effect on performance of: (1) Moving the hub or shroud sidewall; (2) Sidewall-vane clearance leakage; (3) Vaneless space geometry change; and (4) Nozzle cooling flows. Data were obtained for a range of pressure ratios and speeds and are presented in a number of performance maps. Author

**N86-28948#** Turbomeca S. A. - Brevets Szydlowski, Bordes (France).
**COMPRESSORS STUDY: IMPROVING THE EFFICIENCY OF A HIGH PERFORMANCE MULTISTAGE COMPRESSOR Final Report [ETUDE SUR LES COMPRESSORS: AMELIORATION DES RENDEMENTS DE COMPRESSEURS MULTIETAGES A HAUTES PERFORMANCES]**
D. DEHONDT Jun. 1985 27 p In FRENCH
(Contract DRET-82-342)
(ESA-86-97192) Avail: NTIS HC A03/MF A01

The effect of prerotation at the inlet of each stage was tested on a two stage axial compressor. The technical specifications are 45000 turns/min, 3.35 Kg of air/sec, and a compression rate of 12. A mechanical and aerodynamic study was performed in order to reduce the Mach number at the inlet of the rotating blades. The results confirm that the introduction of prerotation in the design improves overall compressor efficiency. ESA

**N86-28949#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris (France).
**PREDICTION OF THE STABILITY PERFORMANCE OF A TURBOREACTOR COMBUSTION CHAMBER Final Report [PREDICTION DES PERFORMANCES DE STABILITE D'UNE CHAMBRE DE TURBOREACTEURS]**
C. FAVREAU, Y. CHAUVEAU, and M. DESAULTY 1985 41 p In FRENCH
(Contract DRET-83-34-502)
(SNECMA-YKC-3269/85; ESA-86-97196) Avail: NTIS HC A03/MF A01

A theoretical prediction method based on the decomposition of the actual combustion chamber in elementary reaction volumes which are described by a model is investigated. Aerodynamic characterization of the chamber, combustion chemistry models, and carburant distribution in the combustion chamber were studied. An algorithm was developed and experimentally verified. The proposed method leads to prediction models which describe CO pollution, efficiency, and combustion stability for a reasonably low computing cost. ESA

# 08

# AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-40681*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**THE MEASUREMENT OF AIRCRAFT PERFORMANCE AND STABILITY AND CONTROL AFTER FLIGHT THROUGH NATURAL ICING CONDITIONS**
R. J. RANAUDO, K. L. MIKKELSEN, R. C. MCKNIGHT, R. F. IDE, A. L. REEHORST (NASA, Lewis Research Center, Cleveland, OH) et al. AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 46 p. Previously announced in STAR as N86-22582. refs
(AIAA PAPER 86-9758)

The effects of airframe icing on the performance and stability and control of a twin-engine commuter-class aircraft were measured by the NASA Lewis Research Center. This work consisted of clear air tests with artificial ice shapes attached to the horizontal tail, and natural icing flight tests in measured icing clouds. The clear air tests employed static longitudinal flight test methods to determine degradation in stability margins for four simulated ice shapes. The natural icing flight tests employed a data acquisition system, which was provided under contract to NASA by Kohlman Systems Research Incorporated. This system used a performance modeling method and modified maximum likelihood estimation (MMLE) technique to determine aircraft performance degradation and stability and control. Flight test results with artificial ice shapes showed that longitudinal, stick-fixed, static margins are reduced on the order of 5 percent with flaps up. Natural icing tests with the KSR system corroborated these results and showed degradation in the elevator control derivatives on the order of 8 to 16 percent depending on wing flap configuration. Performance analyses showed the individual contributions of major airframe components to the overall degradation in lift and drag. Author

**A86-40766**
**THE DESIGN OF A SLIDING MODE CONTROLLER FOR DUTCH ROLL DAMPING IN A NON-LINEAR AIRCRAFT SYSTEM**
P. P. ASLIN, R. J. PATTON (York, University, Heslington, England), and C. M. DORLING (Sheffield, University, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 435-439. refs

The design and application of a sliding mode VSS (variable structure system) controller to the lateral motion subsystem of an RPV are considered. The controller was designed using new results concerning VSS analysis, providing a rigorous design technique combining eigenvalue and eigenvector assignment. In addition, the robustness properties of this control were investigated by using the nonlinear control law with a full-six-DOF aerodynamic model of the aircraft. The degree of insensitivity achieved by the sliding design is examined, and it is shown that the VSS controller provides acceptable performance. The demands placed on the actuators were shown to be small, and little evidence of 'chatter' was apparent. B.J.

**A86-40767**
**THE DESIGN OF MULTI-FUNCTIONAL FLIGHT CONTROLLERS FOR STRUCTURAL LOAD ALLEVIATION**
A. BRADSHAW (Salford, University, England) and S. E. BURGE (British Aerospace, PLC, Weybridge, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 440-445. refs

A summary of a general control system design technique for the class of second-order multivariable systems is presented. This technique is particularly suited to the design of high-performance multi-functional flight control-laws. Indeed, the presentation of real-time analogue computer-microprocessor simulation results demonstrates the performance achievable by the implementation of such control-laws, in that they most satisfactorily effect the required tasks of accurate pitch maneuvering while simultaneously alleviating wing loads induced by the maneuver and by discrete gusts even for naturally unstable aircraft. Author

**A86-40771**

**ON THE RELATIONSHIP BETWEEN ROBUSTNESS TESTS AND THEIR APPLICATION TO HELICOPTER CONTROL SYSTEM DESIGNS**

M. S. TOMBS and I. POSTLETHWAITE (Oxford University, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 464-468. SERC-supported research. refs

Various methods of using singular value inequalities in the frequency domain to analyze the robustness of a control system design are compared, with particular emphasis on the class of possible plant models allowed by those constraints which must be satisfied before an inequality test is applicable. The relationship between Lehtomaki's robustness test and an inverse Nyquist based test is established, the former being a special case of the latter. The combined test as presented in Postlethwaite and Foo (1983) has been demonstrated to apply when a plant has uncertain poles close to the imaginary axis. The tests are compared with respect to their application to a control system design based on an LQG robustness recovery procedure. A helicopter design example is considered which illustrates the degree of usefulness of the different tests, and also allows an evaluation of the LQG design procedure. B.J.

**A86-42785#**

**A DESIGN APPROACH TO A PERFORMANCE SEEKING CONTROL**

P. SHAW, J. FORGROVER (Northrop Corp., Aircraft Div., Hawthorne, CA), D. F. BERG, J. SWAN, S. ADIBHATLA (General Electric Co., Fairfield, CT) et al. AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 14 p. USAF-supported research. refs
(AIAA PAPER 86-1674)

An indirect adaptive control system is being developed that will optimize the performance of a combined aircraft-engine system by minimizing the fuel flow consumption for subsonic and supersonic cruise operation. The indirect approach first perturbs a model of the aircraft-engine system to establish the constrained gradient direction that will maximize the performance improvement rate. A gradient integration algorithm is then used to follow the non-linear gradient direction to optimum performance. The gradient search identifies incremental changes to the current control variable positions which are then transmitted to the control as revised demands. The aircraft and the engine control systems respond to the changes in their schedules by adjusting the control system actuators through normal control operation. The resultant control laws will be modeled and included in a high fidelity, six-degree-of-freedom aircraft-engine simulation incorporating advanced tactical fighter aircraft features. A comprehensive evaluation test plan, which includes an assessment of potentially long-term instability due to unmodeled dynamics, has been developed to evaluate this adaptive control system design. This paper discusses the design approach for an indirect adaptive trim control system which will optimize the performance of a combined aircraft and propulsion system. Author

**A86-42913**

**EIGENSTRUCTURE SYNTHESIS OF AN OBLIQUE WING FLIGHT CONTROL SYSTEM**

G. L. LARSON and K. W. WILLISTON (Rockwell International Corp., Los Angeles, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 660-662. Research supported by Rockwell International Corp.

A flight control system design employing the recently developed linear control techniques of eigenstructure synthesis and command generator tracking is presented for an oblique wing fighter. The eigenvalues governing modal frequency and damping are developed such that the vehicle dynamics are compliant with MIL-F-8785c, 'Flying Qualities of Piloted Aircraft'. Eigenvectors are deterministically developed through output feedback in an attempt to achieve orthogonality, decoupling the symmetric and asymmetric modes of motion. The design is unique in that longitudinal and lateral/directional SAS are developed simultaneously using the same linear model. A simplified constrained controller is examined weighing complexity against performance, after which feed-forward gains are developed to translate desired pilot control to multisurface commands. For example, the NASA Oblique Wing Research Aircraft (OWRA) in transonic flight with the wing highly swept is presented as a demanding situation. Author

**A86-42937**

**DESIGN ISSUES FOR FAULT TOLERANT-RESTRUCTURABLE AIRCRAFT CONTROL**

J. S. ETERNO, J. L. WEISS, D. P. LOOZE, and A. WILLSKY (ALPHATECH, Inc., Burlington, MA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 900-905. refs

Passive and active techniques for fault tolerance and aircraft control are discussed. The advantages of passive robust control and adaptive control for reconstructable flight control systems (RFCSs) are examined. The residual generation of signals, the decision process, and hypothesis test design for the failure detection and identification techniques are described. The uses of control mixer concept, gain scheduling, or artificial intelligence techniques for control system reconfiguration are analyzed. Flight control system (FCS) reconfiguration based on LQ design techniques is considered. An automatic redesign algorithm is utilized to modify the FCS to reconstruct the unfailed aircraft design while directly incorporating control bandwidth constraints; an example of the LQ based approach for fault tolerance and aircraft control is provided. The capabilities of a RFCS which incorporates a failure detection and isolation module, an automatic redesign module, and a robust multivariable flight control system are studied. I.F.

**N86-28090*#** Alphatech, Inc., Burlington, Mass.

**INITIAL DESIGN AND EVALUATION OF AUTOMATIC RESTRUCTURABLE FLIGHT CONTROL SYSTEM CONCEPTS**

J. L. WEISS, D. P. LOOZE, J. S. ETERNO, and D. B. GRUNBERG Jun. 1986 163 p
(Contract NAS1-17411)
(NASA-CR-178064, NAS 1.26:178064; AI-TR-269) Avail: NTIS HC A08/MF A01 CSCL 01C

Results of efforts to develop automatic control design procedures for restructurable aircraft control systems is presented. The restructurable aircraft control problem involves designing a fault tolerance control system which can accomodate a wide variety of unanticipated aircraft failure. Under NASA sponsorship, many of the technologies which make such a system possible were developed and tested. Future work will focus on developing a methodology for integrating these technologies and demonstration of a complete system. Author

**N86-28092*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**EFFECT OF TIME DELAY ON FLYING QUALITIES: AN UPDATE**
R. E. SMITH and S. K. SARRAFIAN Aug. 1986 13 p Proposed for presentation at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88264; H-1351; NAS 1.15:88264) Avail: NTIS HC A02/MF A01 CSCL 01C

Flying qualities problems of modern, full-authority electronic flight control systems are most often related to the introduction of additional time delay in aircraft response to a pilot input. These delays can have a significant effect on the flying qualities of the aircraft. Time delay effects are reexamined in light of recent flight test experience with aircraft incorporating new technology. Data from the X-29A forward-swept-wing demonstrator, a related preliminary in-flight experiment, and other flight observations are presented. These data suggest that the present MIL-F-8785C allowable-control system time delay specifications are inadequate or, at least, incomplete. Allowable time delay appears to be a function of the shape of the aircraft response following the initial delay. The cockpit feel system is discussed as a dynamic element in the flight control system. Data presented indicate that the time delay associated with a significant low-frequency feel system does not result in the predicted degradation in aircraft flying qualities. The impact of the feel system is discussed from two viewpoints: as a filter in the control system which can alter the initial response shape and, therefore, the allowable time delay, and as a unique dynamic element whose delay contribution can potentially be discounted by special pilot loop closures. Author

**N86-28093*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**IMPLEMENTATION AND FLIGHT TESTS FOR THE DIGITAL INTEGRATED AUTOMATIC LANDING SYSTEM (DIALS). PART 2: COMPLETE SET OF FLIGHT DATA**
R. M. HUESCHEN Jul. 1986 330 p
(NASA-TM-87632-PT-2; NAS 1.15:87632-PT-2) Avail: NTIS HC A15/MF A01 CSCL 17G

Five flight tests of the Digital Automated Landing System (DIALS) were conducted on the Advanced Transport Operating System (ATOPS) Transportation Research Vehicle (TSRV)--a modified Boeing 737 Aircraft for advanced controls and displays research. These flight tests were conducted at NASA's Wallops Flight Center using the Microwave Landing System (MLS) installation on Runway 22. This report is primarily a collection of data plots of all performance variables recorded for the entire five flight tests. A description and source of the performance variables is included. Performance variables include inertial data, air data, automatic control commands, control servo positions, sensor data, DIALS guidance and control parameters, and Kalman filter data. This data illustrates low overshoot captures of the localizer for intercept angles of 20 deg, 30 deg, 40 deg, and 50 deg intercept angles, and low overshoot captures of the glideslope slope for 3 deg, 4.5 deg, and 5 deg glideslopes. Flare maneuvers were successfully performed from the various glideslope angles and good decrab maneuvers were performed in crosswinds of 6 knots. In 18 to 20 knot crosswind conditions rudder limiting occurred which caused lateral drifting although heading alignment was achieved. Author

**N86-28094#** Deutsche Lufthansa Aktiengesellschaft, Cologne (West Germany).
**CONTROL SYSTEMS FOR THE AIRBUS DESIGN AND FUNCTIONAL EXPERIENCE [LEITSYSTEME FUER DEN AIRBUS. AUFBAU UND BETRIEBSERFAHRUNG]**
P. H. HELDT 1985 21 p In GERMAN Presented at Fachgespraechs der Gesellschaft fuer Reaktorsicherheit, Munich, West Germany, 8 Nov. 1985
(ESA-86-96936) Avail: NTIS HC A02/MF A01

The design of cockpits of modern passenger aircraft is illustrated by the Airbus 310. Basic rules of aircraft design are given. Important control systems are presented. The status of functional experience is outlined. The crew is taken into account as an integral part in order to correctly understand the global cockpit system. It is shown how the two tasks of pilots (flying and controlling) are integrated in the global concept of cockpit design, and the pilot qualifications required for these tasks are outlined. ESA

**N86-28095#** Societe Nationale Industrielle Aerospatiale, Toulouse (France).
**EIGENVALUES ASSIGNMENT METHOD: AN APPLICATION TO DESIGNING AN AUTOPILOT**
A. BUCHARLES (Departement d'Etudes et de Recherches en Technologie Spatiale, Toulouse, France), J. F. MAGNI, and O. HERAIL 1986 15 p In FRENCH; ENGLISH summary Presented at AFCET Salon Intern. des Tech. et Energies du Futur (SITEF 85), Toulouse, 24-25 Oct. 1985 Submitted for publication
(Contract STPA-83-95024; STPA-84-95016)
(SNIAS-861-111-106; ESA-86-97143) Avail: NTIS HC A02/MF A01

Eigenstructure assignment methods are shown to be a useful tool for computing control laws of multivariable systems. In a first step closed loop eigenvalues are to be assigned. The second step uses the degrees of freedom available on the eigenvectors for optimizing criteria relative to control objectives as output shaping, insensitivity, or disturbance decoupling. The degrees of freedom of eigenvectors are defined and it is shown how to obtain control objectives. The design of an autopilot is detailed to demonstrate the method's efficiency. ESA

**N86-28096#** Societe Nationale Industrielle Aerospatiale, Toulouse (France).
**MAIN FLIGHT CONTROLS [COMMANDES DE VOL PRINCIPALES]**
M. DURANDEAU 1986 30 p In FRENCH Presented at Ecole Nationale de l'Aviation Civile Conf., Toulouse, 22 May 1985
(SNIAS-861-111-111; ESA-86-97147) Avail: NTIS HC A03/MF A01

The A-320 aircraft flight control and avionics systems are illustrated. Safety, maintenance, and systems engineering aspects are listed. ESA

**N86-28950*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**IMPLEMENTATION AND FLIGHT TESTS FOR THE DIGITAL INTEGRATED AUTOMATIC LANDING SYSTEM (DIALS). PART 1: FLIGHT SOFTWARE EQUATIONS, FLIGHT TEST DESCRIPTION AND SELECTED FLIGHT TEST DATA**
R. M. HUESCHEN Jul. 1986 135 p
(NASA-TM-87632-PT-1; NAS 1.15:87632-PT-1) Avail: NTIS HC A07/MF A01 CSCL 01C

Five flight tests of the Digital Automated Landing System (DIALS) were conducted on the Advanced Transport Operating Systems (ATOPS) Transportation Research Vehicle (TSRV) -- a modified Boeing 737 aircraft for advanced controls and displays research. These flight tests were conducted at NASA's Wallops Flight Center using the microwave landing system (MLS) installation on runway 22. This report describes the flight software equations of the DIALS which was designed using modern control theory direct-digital design methods and employed a constant gain Kalman filter. Selected flight test performance data is presented for localizer (runway centerline) capture and track at various intercept angles, for glideslope capture and track of 3, 4.5, and 5 degree glideslopes, for the decrab maneuver, and for the flare maneuver. Data is also presented to illustrate the system performance in the presence of cross, gust, and shear winds. The mean and standard deviation of the peak position errors for localizer capture were, respectively, 24 feet and 26 feet. For mild wind conditions, glideslope and localizer tracking position errors did not exceed, respectively, 5 and 20 feet. For gusty wind conditions (8 to 10 knots), these errors were, respectively, 10 and 30 feet. Ten hands off automatic lands were performed. The standard deviation of the touchdown position and velocity errors from the mean values were, respectively, 244 feet and 0.7 feet/sec. Author

**N86-28951*#** Kansas Univ. Center for Research, Inc., Lawrence.

**INVESTIGATION OF EMPENNAGE BUFFETING**

C. E. LAN, I. G. LEE, and W. H. WENTZ (Wichita State Univ., Kans.) Jul. 1986 81 p
(Contract NAG2-371)
(NASA-CR-177164; NAS 1.26:177164; CRINC-FRL-714-1) Avail: NTIS HC A05/MF A01 CSCL 01C

Theoretical methods of predicting aircraft buffeting are reviewed. For the buffeting due to leading edge vortex breakdown, a method is developed to convert test data of mean square values of fluctuating normal force to buffeting vortex strength through an unsteady lifting-surface theory and unsteady suction analogy. The resulting buffeting vortex from the leading edge extension of an F-18 configuration is used to generate a fluctuating flow field which produces unsteady pressure distribution on the vertical tails. The root mean square values of root bending moment on the vertical tails are calculated for a rigid configuration. Author

**N86-28952*#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.

**THE INTEGRATED MANUAL AND AUTOMATIC CONTROL OF COMPLEX FLIGHT SYSTEMS Status Report, Apr. 1985 - Jun. 1986**

D. K. SCHMIDT 7 Jul. 1986 27 p
(Contract NAG4-1)
(NASA-CR-177086; NAS 1.26:177086) Avail: NTIS HC A03/MF A01 CSCL 01C

The topics of research in this program include pilot/vehicle analysis techniques, identification of pilot dynamics, and control and display synthesis techniques for optimizing aircraft handling qualities. The project activities are discussed. The current technical activity is directed at extending and validating the active display synthesis procedure, and the pilot/vehicle analysis of the NLR rate-command flight configurations in the landing task. Two papers published by the researchers are attached as appendices. E.R.

**N86-28953*#** Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.

**MULTIVARIABLE CONTROL OF A FORWARD SWEPT WING AIRCRAFT M.S. Thesis**

W. W. QUINN Jan. 1986 137 p
(Contract NAG2-297)
(NASA-CR-177112; NAS 1.26:177112; LIDS-TH-1530) Avail: NTIS HC A07/MF A01 CSCL 01C

The impact of independent canard and flaperon control of the longitudinal axis of a generic forward swept wing aircraft is examined. The Linear Quadratic Gaussian (LQG)/Loop Transfer Recovery (LTR) method is used to design three compensators: two single-input-single-output (SISO) systems, one with angle of attack as output and canard as control, the other with pitch attitude as output and canard as control, and a two-input-two-output system with both canard and flaperon controlling both the pitch attitude and angle of attack. The performances of the three systems are compared showing the addition of flaperon control allows the aircraft to perform in the precision control modes with very little loss of command following accuracy. Author

**N86-28954*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

**INDIVIDUAL-BLADE-CONTROL RESEARCH IN THE MIT VTOL TECHNOLOGY LABORATORY 1977-1985 Final Report, Nov. 1977 - Nov. 1985**

N. D. HAM Jun. 1986 40 p
(Contract NSG-2266)
(NASA-CR-177121; NAS 1.26:177121; VTL-TR-196-8) Avail: NTIS HC A03/MF A01 CSCL 01C

A new, advanced system for active control of helicopters and its application to the solution of rotor aerodynamic and aeroelastic problems is described. Each blade is individually controlled in the rotating frame over a wide range of frequencies. Application of the system to gust alleviation, attitude stabilization, vibration alleviation, blade lag damping augmentation, stall flutter suppression, blade flapping stabilization, stall alleviation, and performance enhancement is outlined. The effectiveness of the system in achieving most of these applications is demonstrated by experimental results from wind tunnel tests of a model helicopter rotor with individual blade control. The feasibility of achieving many or all of the applications of individual blade control using the conventional helicopter swash plate is demonstrated, and the necessary control laws are presented. Author

**N86-28955*#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.

**MULTI-INPUT, MULTI-OUTPUT SYSTEM CONTROL FOR EXPERIMENTAL AIRCRAFT Progress Report**

D. K. SCHMIDT and E. L. DUKE 13 Dec. 1985 57 p
(Contract NCC2-288)
(NASA-CR-177017; NAS 1.26:177017) Avail: NTIS HC A04/MF A01 CSCL 01C

Two techniques, direct eigenspace assignment (DEA) and explicit model following (EMF), are used initially to synthesize control laws for the longitudinal dynamics model of a Short Takeoff and Landing (STOL) vehicle in the landing configuration. The vehicle model and the flight control design are presented. The two synthesis techniques are briefly discussed and the handling qualities specifications mapped into the algorithm formulations. The control laws resulting from exercising the algorithms are evaluated in terms of achieved performance and robustness. Since the synthesized control laws involve full state feedback, methodologies were implemented for the control laws using output feedback without adversely affecting performance and robustness. Finally, the salient features of the two design techniques are summarized and the areas that require further investigation are suggested. B.G.

**N86-28956*#** Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.

**MULTIVARIABLE CONTROL OF A TWIN LIFT HELICOPTER SYSTEM USING THE LQG/LTR DESIGN METHODOLOGY**

A. A. RODRIGUEZ and M. ATHANS 1986 8 p
(Contract NAG2-297)
(NASA-CR-177025; NAS 1.26:177025; LIDS-P-1551) Avail: NTIS HC A02/MF A01 CSCL 01C

Guidelines for developing a multivariable centralized automatic flight control system (AFCS) for a twin lift helicopter system (TLHS) are presented. Singular value ideas are used to formulate performance and stability robustness specifications. A linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR) design is obtained and evaluated. Author

**N86-28957*#** Florida Atlantic Univ., Boca Raton. Dept. of Mechanical Engineering.

**AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF ISOLATED ROTOR FLAP-LAG STABILITY IN FORWARD FLIGHT**

G. H. GAONKER, M. J. MCNULTY (Army Research and Technology Labs., Moffett Field, Calif.), and J. NAGABHUSHAN (Indian Inst. of Science, Bangalore) Sep. 1985 31 p Presented at the 11th European Rotorcraft Forum, London, England, 10-13 Sep. 1985
(Contract NCC2-361)
(NASA-CR-177028; NAS 1.26:177028; PAPER-66) Avail: NTIS HC A03/MF A01 CSCL 01C

For flap-lag stability of isolated rotors, experimental and analytical investigations are conducted in hover and forward flight on the adequacy of a linear quasisteady aerodynamics theory with dynamic inflow. Forward flight effects on lag regressing mode are emphasized. A soft inplane hingeless rotor with three blades is tested at advance ratios as high as 0.55 and at shaft angles as high as 20 degrees. In combination with lag natural frequencies, collective pitch settings and flap-lag coupling parameters, the data base comprises nearly 1200 test points (damping and frequency) in forward flight and 200 test points in hover. By computerized symbolic manipulations, an analytic model is developed in substall to predict stability margins with mode identification. It also predicts substall and stall regions to help explain the correlation between theory and data. Author

**N86-28958*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**NONLINEAR CONTROL OF AIRCRAFT**
L. R. HUNT (Texas Technological Univ., Lubbock), G. MEYER, and R. SU 1984 10 p
(Contract NAG2-189; NAG2-203; N00014-76-C-1136)
(NASA-TM-89225; NAS 1.15:89225) Avail: NTIS HC A02/MF A01 CSCL 01C

Transformations of nonlinear systems were used to design automatic flight controllers for vertical and short takeoff aircraft. Under the assumption that a nonlinear system can be mapped to a controllable linear system, a method using partial differential equations was constructed to approximate transformations in cases where exact ones cannot be found. An application of the design theory to a rotorcraft, the UH-1H helicopter, was presented. Author

**N86-28959*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
**FLUTTER PREDICTION FOR A WING WITH ACTIVE AILERON CONTROL Final Report**
K. PENNING and D. R. SANDLIN Jun. 1983 112 p
(Contract NCC4-1)
(NASA-CR-176994; NAS 1.26:176994) Avail: NTIS HC A06/MF A01 CSCL 01C

A method for predicting the vibrational stability of an aircraft with an analog active aileron flutter suppression system (FSS) is expained. Active aileron refers to the use of an active control system connected to the aileron to damp vibrations. Wing vibrations are sensed by accelerometers and the information is used to deflect the aileron. Aerodynamic force caused by the aileron deflection oppose wing vibrations and effectively add additional damping to the system. Author

**N86-28960*#** National Aeronautics and Space Administration, Washington, D.C.
**OPTICAL TECHNOLOGY FOR FLIGHT CONTROL SYSTEMS**
M. MAYANAGI Mar. 1986 29 p Transl. into ENGLISH from Japan Society for Aeronautical and Space Sciences Journal (Japan), v. 32, no. 369, Oct. 1984 p 583-593 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88400; NAS 1.15:88400; ISSN-0021-4663) Avail: NTIS HC A03/MF A01 CSCL 01C

Optical applications to the flight control system including optical data bus, sensors, and transducers are analyzed. Examples of optical data bus include airborne light optical fiber technology (ALOFT), F-5E, YA-7D, MIL-STD-1553 fiber optic data bus and NAL-optic data bus. This NAL-optic data bus is applied to STOL, and its characteristics are stressed. Principles and advantages of optical pulse-digital transducers are discussed. Author

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## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-40226**
**STOLPORT LONDON - A DESIGN FOR SAFETY**
I. BROOM (Gatwick Handling, Ltd., Horley; Plessey Airports, Ltd., Weybridge, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 166-170.

An evaluation is made of the range of design planning and operations integration considerations that have shaped the STOLport currently under construction in the center of London. The STOLport is intended exclusively for commuter airliners that are able to at least match the noise output and IFR runway requirements of the four-engine DHC-7 aircraft. Attention is given to runway design, residential considerations, noise minimization requirements, and navigational resources of the London area. O.C.

**A86-40477**
**FLIGHT SIMULATOR UPGRADES AND MODIFICATIONS**
P. V. PRABHU and N. K. AGARWAL (GMI, Broken Arrow, OK) IN: Simulators; Proceedings of the Conference, Norfolk, VA, March 3-8, 1985 . La Jolla, CA, Society for Computer Simulation, 1985, p. 1-5.

In connection with the arising need for additional capability to train pilots in a flight simulator, a cost-effective alternative to the procurement of a new simulator can be the upgrading modification of an existing simulator. Benefits of such an alternative are related to lower procurement cost and shorter delivery time. Areas of update are discussed, taking into account aircraft modifications, new government standards, new aircraft data, new training requirements, and aspects of maintainability. Questions of industry performance are investigated, and areas of concern are examined. In addition to the solution of other problems, an exact definition of the improvements to be achieved by the upgrade of the simulator needs to be established. G.R.

**A86-42170**
**SOFTWARE POSITION AND VELOCITY LIMITING FOR A SYNERGISTIC SIX DEGREE-OF-FREEDOM MOTION SYSTEM**
D. R. CAMPBELL (Paisley College of Technology, Scotland) Aeronautical Journal (ISSN 0001-9240), vol. 90, April 1986, p. 121-127. refs

The cross-coupling effect of the hardware and software limiting of motion platform hydraulic jacks' velocity and displacement, which leads to spurious cue generation in the range below 2 Hz, has in the past been ignored. It is presently noted that the setting of software limits and the scaling of jack demands with respect to both this limit and the maximum jack demand yields a limiting strategy that maintains acceleration cue directional fidelity; such a simple scheme encompasses a soft limiting approach for motion jerk reduction, and requires negligible extra computing time or storage. O.C.

**A86-42606#**
**A COMPUTATIONAL FLUID DYNAMICS EVALUATION OF TEST CELL RECIRCULATION EFFECTS ON HIGH-BYPASS TURBOFAN ENGINE SURFACE PRESSURE DISTRIBUTIONS**
D. H. HUDDLESTON, G. K. COOPER, and W. J. PHARES (Sverdrup Technology, Inc., Arnold Air Force Station, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p. refs
(AIAA PAPER 86-1384)

A computational fluid dynamics analysis of an engine exhaust/test cell/diffuser combination is presented. The full Reynolds-averaged Navier-Stokes equations are solved by application of a Beam-Warming algorithm on a numerically generated, body-fitted computational grid. Axisymmetric numerical results and correlations with experiment are presented for a high-bypass turbofan engine and for a subscale turbofan model. The correlations with experiment indicate that the current solution technique provides both a qualitative (overall flow field) and quantitative (surface pressure distribution) analysis capability for engine exhaust/test cell/diffuser flows including test cell recirculation. The results presented indicate a potential for applying this technology to the assessment and correction of test cell effects in high-bypass turbofan engine testing. Author

**A86-42661#**

**UHB TECHNOLOGY FLIGHT VALIDATION PROGRAM**

R. VANT RIET, W. T. LEWERENZ, and J. E. DONELSON (Douglas Aircraft Co., Long Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p.
(AIAA PAPER 86-1473)

An overview of the development of an Ultra High Bypass (UHB) technology demonstrator is presented. The potential benefits and critical technology issues of UHB technology are reviewed. The structural modifications required to convert an MD-80 into a flight demonstration vehicle are described. The goals and schedule of the upcoming flight test program are presented. Author

**A86-42769#**

**A TURBINE ENGINE INLET VIEWING SYSTEM**

R. A. BELZ, C. W. BRASIER, P. J. MURPHY, and T. D. DAVIS (Sverdrup Technology, Inc., Arnold Air Force Station, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1647)

A video imaging system has been developed for turbine engine testing at the Arnold Engineering Development Center to allow observation of individual fan blades, stator blades, and the spinner surface area while the engine is running. The system utilizes off-the-shelf hardware including a strobed laser light source, a fiber-optical cable, and a high-sensitivity video camera to view the inlet in stop motion. Laser strobing is synchronized to the engine rotation for fan and spinner analysis. The system was used to observe ice buildup and shedding on the fan blades and spinner during an engine icing test. Blade-case rubbing was also observed during the test. The strobed laser system is described, ice formations observed on the spinner and fan blades are presented, and applications and planned future improvements to the system are described. Author

**A86-42814#**

**CHARACTERIZATION OF FUEL SPRAYS USING A HIGH-RESOLUTION PATTERNATOR**

J. B. MCVEY, S. RUSSELL, and J. B. KENNEDY (United Technologies Research Center, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 17 p. refs
(AIAA PAPER 86-1726)

The features of a high-resolution patternation system used for measuring the spatial distribution of mass flux delivered by large-volume-flow gas turbine engine fuel injectors are described. The patternation system is based on the use of extractive probing by means of a multi-point sampling rake. Testing is conducted under ambient pressure conditions. Results of tests conducted to verify the capabilities of the system are presented.Applications of the system to establish the impact of injector aerodynamic and hydraulic design features on spray uniformity are discussed. Author

**A86-42819#**

**THEORETICAL AND EXPERIMENTAL INVESTIGATION OF TEST CELL AERODYNAMICS FOR TURBOFAN APPLICATIONS**

A. I. KARAMANLIS, J. S. SOKHEY, T. C. DUNN, and D. C. BELLOMY (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Research supported by the General Electric Co. refs
(AIAA PAPER 86-1732)

This paper describes aerodynamic design, model testing and full scale checkout of a General Electric aircooled exhaust turbofan test facility. The purpose of the research and development work reported herein is to modify the existing test cell configuration to accept high and low bypass ratio turbofan engines with or without afterburner. A brief description of the scale model tests including engine simulation, model test facility and data reduction is given. The comparison of test cell characteristics, i.e., Front Cell Velocity Distortion, Front Cell Depression, Air Flow Rate, Exhaust System Flow Mixing and Temperatures between the model scale and full scale tests is presented. The theoretical results from engine/exhaust collector inviscid and viscous flow analyses, which were used to obtain preliminary exhaust system performance data are also presented. Correlations between full scale and model scale data reveal that the performance of a full scale test cell can be predicted using model scale tests thereby reducing test cell development costs. Author

**N86-28099*#** National Aeronautics and Space Administration, Washington, D.C.

**CRYOGENIC WIND TUNNELS: PROBLEMS OF CONTINUOUS OPERATION AT LOW TEMPERATURES**

D. FAULMANN Jun. 1986 52 p Transl. into ENGLISH of "Souffleries Cryogeniques Problemses Lies au Fonctionnement Continue en Basse Temperature" rept. OA-9/5007-AYD, DERAT-9/5007-DY ONERA, Toulouse, France, Jun. 1980 p 1-18 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88446; NAS 1.15:88446; OA-9/5007-AYD; DERAT-9/5007-DY) Avail: NTIS HC A03/MF A01 CSCL 14B

The design of a cryogenic wind tunnel which operates continuously, and is capable of attaining transonic speeds at generating pressures of about 3 bars is described. Its stainless steel construction with inside insulation allows for very rapid temperature variations promoted by rapid changes in the liquid nitrogen flow. A comparative study of temperature measuring probes shows a good reliability of thin sheet thermocouples. To measure fluctuations, only a cold wire makes it possible to record frequencies of about 300 Hz. The use of an integral computer method makes it possible to determine the impact of the wall temperature ratio to the adiabatic wall temperature for the various parameters characterizing the boundary layer. These cases are processed with positive and negative pressure gradients. Author

**N86-28102#** Department of the Navy, Washington, D. C.

**AIRCRAFT BARRICADE Patent**

P. R. DIGIOVANNIANTONIO, inventor (to Navy) and W. J. ZIMMER, inventor (to Navy) 28 Jan. 1986 4 p Supersedes AD-D011316
(AD-D012194; US-PATENT-4,566,658; US-PATENT-APPL-SN-519421; US-PATENT-CLASS-244-110)
Avail: US Patent and Trademark Office CSCL 01E

A webbing system is disclosed for use as an aircraft barricade wherein a plurality of rectangularly-shaped engaging loops are arranged in an alternating, multi-planar array and suspended across a landing area in the path of an approaching aircraft upon an assembly of support loops stretched between a pair of stanchions and connected on either side to an energy absorbing device. Slidably connected along upper and lower horizontal components of the support loops, the engaging loops are free to move laterally along the support loops toward the longitudinal axis of the aircraft when penetrated by the fuselage so that the aircraft is ensnared about its wings by the loops with equalized loading and its forward motion arrested. GRA

**N86-28961*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**INTERFACE OF THE TRANSPORT SYSTEMS RESEARCH VEHICLE MONOCHROME DISPLAY SYSTEM TO THE DIGITAL AUTONOMOUS TERMINAL ACCESS COMMUNICATION DATA BUS**

W. C. EASLEY and J. S. TANGUY (PRC Kentron, Inc., Hampton, Va.) May 1986 34 p refs
(NASA-TM-87728; NAS 1.15:87728) Avail: NTIS HC A03/MF A01 CSCL 14B

An upgrade of the transport systems research vehicle (TSRV) experimental flight system retained the original monochrome display system. The original host computer was replaced with a Norden 11/70, a new digital autonomous terminal access communication (DATAC) data bus was installed for data transfer between display system and host, while a new data interface method was required.

The new display data interface uses four split phase bipolar (SPBP) serial busses. The DATAC bus uses a shared interface ram (SIR) for intermediate storage of its data transfer. A display interface unit (DIU) was designed and configured to read from and write to the SIR to properly convert the data from parallel to SPBP serial and vice versa. It is found that separation of data for use by each SPBP bus and synchronization of data tranfer throughout the entire experimental flight system are major problems which require solution in DIU design. The techniques used to accomplish these new data interface requirements are described. Author

**N86-28962#** Royal Aircraft Establishment, Farnborough (England).

**A NUMERICAL STUDY OF THE AERODYNAMIC INTERFERENCE OF A MODEL SUPPORT SYSTEM USED IN THE RAE 5 METRE WIND TUNNEL**

B. C. HARDY 5 Sep. 1985 30 p
(AD-A165671; RAE-TM-AERO-2046; BR97527; ESA-86-97105)
Avail: NTIS HC A03/MF A01

Lift interference effects of under-wing strut guards were studied using panel methods. Unexpected reduction in interference with increase in lift beyond a certain value is accounted for by a sweep dependent, nonlinear lift contribution. The level of agreement between theory and experiment shows that the mutual lift and the displacement effects need to be considered. Further comparisons between the calculation method and experiment are necessary to establish how much of the remaining discrepancy in calculations is due to the shortcomings of the method and how much to uncertainties in the experimental data. ESA

**N86-28963#** Resource International, Inc., Columbus, Ohio.

**MECHANISTIC METHODOLOGY FOR AIRPORT PAVEMENT DESIGN WITH ENGINEERING FABRICS. VOLUME 2: ADVANCED CONCEPTS, VALIDATION AND CRITERIA Final Report**

K. MAJIDZADEH, G. J. ILVES, and V. R. KUMAR 7 May 1986 95 p
(Contract DTFA01-81-C-10043)
(DOT/FAA/PM-84/9,II-VOL-2) Avail: NTIS HC A05/MF A01

This report is Volume 2 of a two volume set dealing with the application of non-woven fabrics to rigid airport pavements to control and/or retard the development of reflection cracking of flexible overlays due to both thermal stresses and load-associated fatigue. This volume describes the development of a new viscoelastic analysis model for the analysis of thermal cracking that utilizes fundamental material properties and does not rely on phenomenological distress functions. The methods developed in this work as well as those presented in Phase 1 (Volume 1), have been validated on one airport and four highway projects. The validation is described in this report and shows that the developed analysis models predict the reflection cracking phenomenon for all projects very well. This report also describes the laboratory evaluation of a fiber-asphalt SAMI layer that shows promise for use in reflection cracking control. Finally, specifications for material properties, testing procedures, and construction methods are presented. Author

**N86-28964*#** National Aeronautics and Space Administration, Washington, D.C.

**TESTS WITH THREE-DIMENSIONAL ADJUSTMENTS IN THE RECTANGULAR WORKING SECTION OF THE FRENCH T2 WIND TUNNEL WITH AN AS 07-TYPE SWEPT-BACK WING MODEL**

A. BLANCHARD, M. J. PAYRY, and J. F. BREIL Jul. 1986 161 p Transl. into ENGLISH of "Essais d'Adaptation Tridimensionnelle de la Veine Rectangulaire de la Soufflerie T2 en Presence d'une Maquette d'Aile en Fleche du Type AS 07" rept. OA-34/3075, DERAT-12/5015-DN ONERA, France, Nov. 1985 p 1-24 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-88442; NAS 1.15:88442; OA-34/3075; DERAT-12/5015-DN) Avail: NTIS HC A08/MF A01 CSCL 14B

The results obtained on the AS 07 wing and the working section walls for three types of configurations are reported. The first, called non-adapted, corresponds to the divergent upper and lower rectilinear walls which compensate for limit layer thickening. It can serve as a basis for complete flow calculations. The second configuration corresponds to wall shapes determined from calculations which tend to minimize interference at the level of the fuselage. Finally, the third configuration, called two-dimensional adaptation, uses the standard method for T2 profile tests. This case was tested to determine the influence of wall shape and error magnitude. These results are not sufficient to validate the three-dimensional adaptation; they must be coordinated with calculations or with unlimited atmosphere tests. Author

**N86-28969#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Experimentelle Stroemungsmechanik.

**THE EFFECT OF A SPLITTER PLATE AS BOUNDARY LAYER REMOVAL SYSTEM IN HALF-MODEL TESTING**

H. BIPPES Sep. 1985 29 p
(DFVLR-FB-85-64; ISSN-0171-1342; ESA-86-97454) Avail: NTIS HC A03/MF A01; DFVLR, Cologne, West Germany, DM 10.50

The effect of a splitter plate as boundary layer removal system in half-model testing is investigated. The experiments are performed on a rectangular wing in the range of maximum lift in subsonic flow. Oil flow patterns display the footprints of a complicated three-dimensional secondary flow in the neighborhood of the model to wall junction. This secondary flow leads to a considerable increase of local lift. The data analysis reveals that its intensity depends on the vorticity of the free shear layer separating from the suction side of the wing and the spanwise variation of the circulation, but only slightly on the thickness of the boundary layer on the splitter plate. Comparison with tests without splitter plate shows that under the test conditions investigated the use of the splitter plate is not an effective means for improving the mirror conditions in half-model testing. ESA

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# ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-40515*** Alabama Univ., Huntsville.
**AN ORBITAL MANEUVERING VEHICLE SIMULATOR**
W. TEOH, J. WALLS (Alabama, University, Huntsville), T. BRYAN, F. ROE (NASA, Marshall Space Flight Center, Huntsville, AL), and N. SHIELDS (Essex Corp., Huntsville, AL) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 6-14 to 6-23.

The Orbital Maneuvering Vehicle (OMV) is a teleoperated vehicle designed to dock with a target vehicle in space to peform certain tasks. This vehicle is not yet in production, but a simulator of the OMV is located at Marshall Space Flight Center (MSFC). The MSFC facility provides a realistic simulation of the OMV. Various docking maneuvers can be studied in some detail. A special robot has been constructed that provides a moving target for the simulator to dock with. This facility is valuable for conducting studies on the OMV; it also is excellent for personnel training. Author

**A86-40581*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**SYSTEM AND TECHNOLOGY CONSIDERATIONS FOR SPACE-BASED AIR TRAFFIC SURVEILLANCE**
A. VAISNYS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 31-36. FAA-sponsored research.
(AIAA PAPER 86-1170)

This paper describes the system trade-offs examined in a recent study of space-based air traffic surveillance. Three system options, each satisfying a set of different constraints, were considered. The main difference in the technology needed to implement the three systems was determined to be the size of the spacecraft antenna aperture. It was found that essentially equivalent position location accuracy could be achieved with apertures from 50 meters down to less than a meter in diameter, depending on the choice of signal structure and on the desired user update rate. Author

**A86-40612*#** Lockheed-California Co., Burbank.
**DEVELOPMENT OF A REUSABLE, FLIGHT-WEIGHT CRYOGENIC FOAM INSULATION SYSTEM**
P. S. MCAULIFFE (Lockheed-California Co., Burbank), R. C. DAVIS, and A. H. TAYLOR (NASA, Langley Research Center, Hampton, VA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 11 p. refs
(AIAA PAPER 86-1189)

Attention is given to a light weight foam insulation system applicable to reusable cryogenic propellant tankage for hypersonic aircraft and space launch vehicles. The insulation system consists of nominally sized blocks of a high temperature-resistant polymethacrylimide foam that is wrapped with a vapor-impermeable membrane of Kapton-aluminum-Kapton laminate, which is adhesively bonded to the outer propellant tank wall. Test results are presented which indicate that this insulation system is capable of enduring a Mach 5 service environment without structural cracking, deterioration, or loss of performance. O.C.

**A86-41274**
**MASTERING THE TRANSATMOSPHERE**
J. W. CANAN Air Force Magazine (ISSN 0730-6784), vol. 69, June 1986, p. 48-54.

The National Aerospace Plane (NASP) program has been organized at Wright-Patterson Air Force Base in order to develop the technologies that can in due course be integrated into a family of highly versatile transatmospheric, hypersonic cruise/orbital speed manned craft. In addition to serving as satellite launchers, NASP vehicles could be employed in such missions as reconnaissance, global interdiction, and interception of attacking space forces. NASP transatmospheric vehicles are expected to require far less logistical support than the current Space Shuttles, and could be launched on short notice from dispersed and accessible runways. The earliest operational date expected for a NASP craft is, however, 1995. O.C.

**A86-42938*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FAILURE DETECTION AND ACCOMMODATION IN STRUCTURAL DYNAMICS SYSTEMS USING ANALYTIC REDUNDANCY**
J. P. WILLIAMS and R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 906-910. refs

The concept of analytic redundancy is extended to identify nonzero constant output failures in large spacecraft active control sensors and actuators, using a set of distributed sensors which do not nominally produce equivalent signals but are related through the structural dynamics of the system. The suboptimal technique uses a Sequential Probability Ratio Test on the residual sequence of a Kalman filter based on a modal structure model, to determine failure of a component based on an assumed failure hypothesis. The specific failure is identified and then the Kalman filter gains are reconfigured for the identified remaining working sensor set. Experimental data using an apparatus whose dynamics are representative of a large spacecraft show the nominal filter performance under failed and unfailed conditions. R.R.

**N86-28239#** Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
**FLAME DRIVING OF LONGITUDINAL INSTABILITIES IN DUMP TYPE RAMJET COMBUSTORS**
U. G. HEDGE, D. REUTER, B. R. DANIEL, and B. T. ZINN *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 307-316 Oct. 1985 Previously announced in IAA as A86-19839
(Contract N00014-84-K-0470)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Coaxial, dump type ramjet combustors are often prone to combustion instability problems that can seriously affect their performance. Low frequency instabilities which represent one of the most common types of instabilities encountered are discussed. In particular, the coupling between cone-like flames often encountered in dump type combustors and longitudinal acoustic fields is studied. A variety of experimental techniques, including high speed Schlieren and shadow photography, CH radiation emission and acoustic pressure measurements are used. A strong coupling between the flame response and certain acoustic natural frequencies of the experimental set up is observed. These observations shed new light on flame/acoustic mode interactions in a ramjet combustor-like environment and the limitations of current state of the art theoretical models of this phenomenon. Author

**N86-28240#** California Inst. of Tech., Pasadena.
**NONLINEAR ANALYSIS OF PRESSURE OSCILLATIONS IN RAMJET ENGINES**
V. YANG and F. E. C. CULICK *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 317-329 Oct. 1985
(Contract N00014-84-K-0434)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Pressure oscillations in ramjet engines have been studied using an approximate method which treats the flow fields in the inlet and the combustor separately. The acoustic fields in the combustor are expressed as syntheses of coupled nonlinear oscillators corresponding to the acoustic modes of the chamber. The influences of the inlet flow appear in the admittance function at the inlet/combustor interface, providing the necessary boundary condition for calculation of the combustor flow. A general framework dealing with nonlinear multi-degree-of-freedom system has also been constructed to study the time evolution of each mode. Both linear and nonlinear stabilities are treated. The results obtained serve as a basis for investigating the existence and stabilities of limit cycles for acoustic modes. As a specific example, the analysis is applied to a problem of nonlinear transverse oscillations in ramjet engines. Author

**N86-28241#** Flow Research, Inc., Kent, Wash.
**LARGE EDDY SIMULATIONS OF FLOW IN A RAMJET COMBUSTOR**
W. H. JOU and S. MENON *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 331-339 Oct. 1985
(Contract N00014-84-C-0359)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Cold flow simulations are performed for the flow inside a ramjet combustor with dump. The objective is to develop a numerical simulation code that can be used to study the complex interaction between acoustic waves and large vortex structures in such a device. The compressible Navier-Stokes equations are solved using a MacCormack semi-implicit scheme. Beginning with a flow at rest, the flow seems to reach a state of stationary variation ten longitudinal acoustic cycles after the exit pressure is lowered to a prescribed value. Vorticity contour plots reveal that the shear layer behind the backward-facing step rolls up into large vortices. These vortices go through two pairings before being convected into the wall layer. The frequency of the vortex after the second pairing is near the range of the jet preferred mode. The unsteady component of the dilation field is chosen as a quantity that characterizes the acoustic component of the motion. Contour plots of the dilation field show that it is dominated by the quadrupole sources associated with rolled up vortices. The long-wavelength standing waves cannot be detected using this method. Examination of the two-point, two-time correlation of the pressure variations at several points in the flow field gives evidence that the long-wavelength acoustic waves close to the jet preferred mode frequency have been excited. Author

**N86-28242#** Naval Research Lab., Washington, D. C. Lab. for Computational Physics.
**ACOUSTIC-VORTEX INTERACTIONS IN AN IDEALIZED RAMJET COMBUSTOR**
K. KAILASANATH, J. GARDNER, J. BORIS, and E. ORAN *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 341-350 Oct. 1985
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Results are presented of numerical simulations performed to isolate and study the interaction between acoustic waves and large scale coherent vortex structures in an idealized ramjet combustor. A strong coupling between the acoustic modes of the chamber and large scale vortical structures is observed. The results in the early part of the calculations are indicative of an unforced natural vortex growth at a frequency close to the acoustic frequency. With time, the acoustic modes shift the frequency of the most amplified mode into resonance with the acoustic mode. The location in space where the modes grow can also be shifted by acoustic forcing. An interesting new feature that is observed is a low frequency mode corresponding to the passage of the vortex structures through the choked exit. This results in a major alteration of the merging pattern of the vortices. Author

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## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-40251**
**ALUMINIUM-LITHIUM ALLOYS III; PROCEEDINGS OF THE THIRD INTERNATIONAL ALUMINIUM-LITHIUM CONFERENCE, OXFORD UNIVERSITY, ENGLAND, JULY 8-11, 1985**
C. BAKER, ED. (Alcan International, Ltd., Banbury, England), P. J. GREGSON, ED. (Southampton, University, England), S. J. HARRIS, ED. (Nottingham University, England), and C. J. PEEL, ED. (Royal Aircraft Establishment, Farnborough, England) Conference organized and sponsored by the Institute of Metals. London, Institute of Metals, 1986, 640 p. For individual items see A86-40252 to A86-40315.

The papers presented in this volume focus on the fundamental metallurgy, production and processing aspects, and aerospace applications of Al-Li alloys. Emphasis is placed on mechanical properties and fabrication parameters in comparison with the existing aerospace alloys as well as requirements and specific applications of the alloys in airframes and engines in fixed-wing aircraft and helicopters. Papers are included on the production of aluminum-lithium alloys with high specific properties, fatigue crack propagation in mechanically alloyed Al-Li-Mg alloys, superplastic aluminum-lithium alloys, fundamental aspects of hardening in Al-Li and Al-Li-Cu alloys, and mechanical properties of Al-Li-Zn-Mg alloys. V.L.

**A86-40252**
**OVERVIEW**
D. LITTLE (Airbus Industrie, Blagnac, France) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 15-21.

The role of new metallic and nonmetallic composite materials in reducing the weight and increasing the payload capabilities of aircraft is examined, with particular attention given to aluminum-lithium alloys. A four-step program conducted at the Airbus Industrie, France, with the aim of introducing aluminum-lithium alloys progressively into all aircraft is reviewed. The program includes (1) substitution of Al-Li alloys for conventional alloys in noncritical parts; (2) substitution of Al-Li alloys in non-fatigue-critical parts; (3) substitution of Al-Li alloys for current alloys in fatigue-critical structures; and (4) new design solutions to make optimum use of Al-Li alloy properties. V.L.

**A86-40255**
**PRODUCTION OF ALUMINIUM-LITHIUM ALLOY WITH HIGH SPECIFIC PROPERTIES**
P. MEYER and B. DUBOST (Cegedur Pechiney, Centre de Recherches et Developpement, Voreppe, France) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 37-46. refs

Reducing the weight of aircraft structure through the use of lighter advanced materials has become a major goal. Pechiney's extensive research and development program has resulted in a new family of aluminum-lithium alloys. Thanks to the combination of efficient D.C. casting, alloy design coprecipitation strengthening and structural control, these CP 27X alloys overcome the previously identified brittleness of Al-Li alloys and already match most current goals for a wide use on aircraft. Author

**A86-40256**

### 'ALITHALITE' ALLOYS - PROGRESS, PRODUCTS AND PROPERTIES

P. E. BRETZ and R. R. SAWTELL (Alcoa Laboratories, Alcoa Center, PA) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 47-56. refs

Alithalite Al-Li alloys are being developed by Alcoa to meet four first-generation objectives: low-density replacements for 2024-T3X, 7075-T6X, and 7075-T73X products and a moderate-strength, minimum density alloy. One alloy, recently registered as 2090 (Al-2.7 wt pct Cu-2.2 pct Li-0.12 pct Zr), has been introduced as a replacement for 7075-T6X plate, sheet, and extrusion product forms. This paper concentrates on discussing the metallurgical and engineering property characteristics of this alloy. Progress toward developing alloys to meet the other objectives also will be outlined, with emphasis given to property achievements. Author

**A86-40267**

### ADHESIVE BONDING OF ALUMINIUM-LITHIUM ALLOYS

D. J. ARROWSMITH, R. J. DAVIES (Aston, University, Birmingham, England), A. W. CLIFFORD, and D. A. MOTH (Admiralty Research Establishment, Portland, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 148-151. refs

Al-2.35 pct Li-1.13 pct Cu alloy was adhesively bonded using established chromic acid anodizing and phosphoric acid anodizing processes. A new process consisting of sulfuric acid anodizing followed by a phosphoric acid dip was also used. The initial bond strengths and durabilities of lap shear joints of aluminum-lithium and aluminum-magnesium alloys were found to be similar. The anodizing characteristics of aluminum-lithium and aluminum-magnesium alloys were also found to be similar. Author

**A86-40280**

### COMPARISON OF CORROSION BEHAVIOUR OF LITHIUM-CONTAINING ALUMINIUM ALLOYS AND CONVENTIONAL AEROSPACE ALLOYS

P. L. LANE, J. A. GRAY, and C. J. E. SMITH (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986. p. 273-281. refs

Marine exposure and accelerated laboratory corrosion tests have been used to compare the corrosion behavior of some Al-Li-Mg-Cu alloys with conventional aerospace alloys. The pitting resistance of Al-Li-Mg-Cu alloys in neutral salt fog and under total immersion conditions is superior to that of conventional alloys. In a marine environment, Al-Li-Mg-Cu alloys exhibit exfoliation corrosion; the sheet material is particularly susceptible and resistance to exfoliation is improved by overaging. Stress corrosion cracking properties are similar to conventional alloys. Al-Li-Mg-Cu alloys are galvanically compatible with other aluminum alloys. Author

**A86-40291**

### TEXTURES DEVELOPED IN AL-LI-CU-MG ALLOY

M. J. BULL and D. J. LLOYD (Alcan International, Ltd., Kingston, Canada) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 402-410. refs

The crystallographic texture development of alloy 8090 as a function of rolling (hot and cold), cross-rolling (hot and cold) and after various thermal treatments is discussed. Where applicable, comparison will be made with other high strength aluminium alloys subjected to similar thermo-mechanical treatments. Author

**A86-40303**

### COARSENING OF DELTA PRIME, T1, S PRIME PHASES AND MECHANICAL PROPERTIES OF TWO AL-LI-CU-MG ALLOYS

M. AHMAD and T. ERICSSON (Linkoping Institute of Technology, Sweden) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London. Institute of Metals, 1986, p. 509-515. Research supported by the Styrelsen for Teknisk Utveckling and Saab-Scania, AB. refs

The aging response of the alloy has been determined by hardness measurements. The microstructures developed after various artificial aging treatments were studied by TEM. The effect of prestretch on the precipitation of S prime and T1 was investigated. The density of S prime and T1 was increased due to the prestretch. A significant improvement in the yield strength was obtained by stretching prior to aging. The ultimate tensile strength was also slightly improved, while the elongation to fracture was slightly reduced. In the under-aged condition deformation was localized within slip bands. The deformation was homogeneous for peak aged conditions. The fracture surfaces of failed tensile specimens were studied with the help of scanning electron microscopy (SEM). The mechanical properties and fracture behavior of the alloy has been correlated with microstructural features. Author

**A86-40304**

### DEVELOPMENT OF PROPERTIES WITHIN HIGH-STRENGTH ALUMINIUM-LITHIUM ALLOYS

P. J. GREGSON (Southampton, University, England), C. J. PEEL, and B. EVANS (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 516-523. refs

Further additions of magnesium and/or copper to Lital 'A' are shown to lead to high strengths satisfying DTD XXXB requirements; the extent of these additions is limited by the homogenization process. Optimum properties in the unstretched sheet are associated with the coprecipitation of delta prime and S phase. Author

**A86-40305**

### AGE HARDENING BEHAVIOR OF DTD XXXA

K. WELPMANN, M. PETERS (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany), and T. H. SANDERS, JR. (Purdue University, West Lafayette, IN) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 London, Institute of Metals, 1986, p. 524-529. refs

Results of a study of the artificial and natural aging behavior of DTD XXXA, an Al-Li alloy considered for applications in the next generation military and transport aircraft, are reported. During natural aging, a strength increase is observed after an incubation period of about 30 hr, which is attributed to the formation and growth of Guinier-Preston zones. The artificial age hardening curves in the range 150-185 C have a plateau before reaching a peak; the plateau coincides with a minimum in elongation. The yield stress increases beyond the plateau and the corresponding increase of the elongation are attributed to an accelerated growth of S-prime particles. Stretching before artificial aging leads to a higher strength, which is thought to be a result of a more homogeneous distribution of the S-prime phase. V.L.

A86-40306

### EFFECT OF PRECIPITATION ON MECHANICAL PROPERTIES OF AL-LI-CU-MG-ZR ALLOY

J. WHITE, W. S. MILLER, I. G. PALMER (Alcan International, Ltd., Banbury, England), R. DAVIS, and T. S. SAINI (Alcan International, Ltd., Gerrards Cross, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 530-538. refs

Low ductility and poor fracture toughness in binary Al-Li alloys have been attributed to intense coplanar slip associated with the precipitation of the coherent delta prime phase. The introduction of additional precipitation may disperse planar slip and hence result in an improvement in the relationship between strength, ductility, and fracture toughness in more complex alloys. One such alloy system currently under development is Al-Li-Cu-Mg-Zr where S prime and T1 phases have been observed to nucleate heterogeneously on dislocations and subgrain boundaries. The present work examines the effect of cold work prior to aging at 190 C on the mechanical properties of commercially produced Al-Li-Cu-Mg-Zr sheet. Author

A86-40312

### DEFORMATION AND FRACTURE IN AL-LI BASE ALLOYS

W. S. MILLER, M. P. THOMAS (Alcan International, Ltd., Banbury, England), D. J. LLOYD, and D. CREBER (Alcan International, Ltd., Kingston, Canada) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 584-594. refs

The deformation structures observed in Al-Li and Al-Li-Cu-Mg-Zr alloys are investigated with a view to determining the causes of the low ductility and fracture toughness of Al-Li-based alloys. An analysis of results, obtained by in-situ fracture surface analysis techniques, indicates that the low ductility and toughness of Al-Li alloys is largely due to grain-boundary segregation. Ways of reducing the effect of grain-boundary segregation on fracture behavior are discussed. V.L.

A86-40345

### EFFECT OF MOISTURE ON THERMAL PROPERTIES OF COMPOSITE MATERIALS FOR AEROSPACE APPLICATIONS

M. MARCHETTI, G. MAURA (Roma I, Universita, Rome, Italy), M. PAURI (Ancona, Universita, Italy), and F. VENIALI (Roma II, Universita, Rome, Italy) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 201-206. Research sponsored by the Ministero della Pubblica Istruzione. refs

The effects of the fiber characteristics, water absorption and thermal spikes on the porosity and variations in the glass transition temperature (Tg) of composite materials were examined experimentally. Samples of fiber glass reinforced materials, carbon fiber reinforced plastic and Kevlar fiber reinforced laminates were exposed on two sides to water vapor. The samples were withdrawn at specified intervals and weighed. Equivalent specimens were subjected to thermal spikes ranging from 20-120 deg lasting for 5 min for seven times each. Other samples were degassed and sealed in containers before being exposed to the thermal spikes. Porosity did not change with the thermal spikes, which are typical of conditions experienced by materials on spacecraft and high performance aircraft. The apparent Tg values of epoxy matrices fell with water vapor absorption. Exposure to thermal spikes inhibited recovery from water vapor absorption, while recovery did occur in samples which absorbed moisture at room temperature. M.S.K.

A86-40364

### CARBON-CARBON COMPOSITES FOR BRAKING [LES CARBONE-CARBONE POUR LE FREINAGE]

L. HERAUD and B. BROQUERE (SocieteEuropeenne de Propulsion, Saint-Medard-en-Jalles, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 440-446. In French. refs

The first use of Carbon-carbon composites (CCC) brake components in aircraft was on the Concorde, realizing a weight savings of 600 kg. CCC brakes are now used on the Mirage 2000 and on the Airbus 300 series aircraft. Brakes are intended to absorb and dissipate, by thermal emission, the kinetic energy of a moving vehicle. The thermal mass and specific mass of CCC are higher and lower than those of steel and coopper, respectively. Furthermore, thermomechanical properties of CCC do not degrade at high temperatures. CCC has a coefficient of friction of 0.3-0.6, similar to other braking materials, and remains stable under prolonged braking. Recent experience and expanded production of CCC materials have been sufficient to make the cost of CCC brakes competitive with other materials. The success of CCC brakes in aircraft and formula 1 racing cars is expected to lead to a widespread adoption of CCC brakes in cars. M.S.K.

A86-40487

### CARBON FIBRES AND THEIR COMPOSITES

E. FITZER, ED. (Karlsruhe, Universitaet, West Germany) Berlin and New York, Springer-Verlag, 1985, 307 p. For individual items see A86-40488 to A86-40499.

The present conference considers topics encompassing the fields of advanced composite reinforcing fibers, polymeric matrices, fabrication and design methodologies for carbon fiber-reinforced composites (CFRPs), the testing and fracture behavior of CFRPs, CFRP applications in aerospace, and the R&D activities in carbon fiber production of Brazil, India, China, and South Korea. Specific discussions are presented concerning the effect of matrix resin choice on prepreg processing, the development of thermosetting polyimide matrix resins, autoclave compression molding, design preparations for large space structures, CFRP testing and properties optimization, industrial and marine applications of carbon fiber reinforcements, and biomedical applications of CFRP. O.C.

A86-40488

### TECHNICAL STATUS AND FUTURE PROSPECTS OF CARBON FIBRES AND THEIR APPLICATION IN COMPOSITES WITH POLYMER MATRIX (CFRPS)

E. FITZER (Karlsruhe, Universitaet, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 3-45. refs

The structure of carbon fibres and its dependence on the presursor material gives an understanding of the properties of today's commercial fibre types. The possibilities of further improvement are considered from theoretical viewpoint as well as starting from the properties of PAN based fibres of the new generation must in development. The problem of correct terminology of this promising new material is raised. Economic considerations are presented, comprising a review on present technology, the world demand and the price situation. Finally, the various fields for application of carbon fibres - such as aerospace, transportation, sport, machinery and apparatus, cryogenic technology, as well as medicine - are discussed briefly. Author

A86-40498

### EXPERIENCES IN FRG IN AEROSPACE APPLICATION

K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 206-228.

Attention is given to the experience gained in West Germany to date with CFRPs' fiber, matrix resin, and fiber-resin interface characteristics. Attention is given to space structures applications such as the Intelsat V series satellites' solar cell array structure, as well as the Tornado fighter aircraft's taileron, a technology development CFRP fighter cockpit, and helicopter rotor blades and driveshafts. Also noted are recent advancements in CFRP fabrication and quality assurance techniques. O.C.

**A86-40575**

### A SIMPLIFIED RESIDUAL STRESS MODEL FOR PREDICTING FATIGUE CRACK GROWTH BEHAVIOR AT COLDWORKED FASTENER HOLES

X. SU, M. GU, and M. YAN (Institute of Aeronautical Materials, Beijing, People's Republic of China) Fatigue and Fracture of Engineering Materials and Structures (ISSN 8756-758X), vol. 9, no. 1, 1986, p. 57-64. refs

This paper presents an investigation of the fatigue crack growth (FCG) behavior at fastener holes in a high strength steel, 30CrMnSiNi2A, before and after a cold-expansion process. The fatigue life of coldworked specimens was significantly increased compared to noncoldworked ones and increased the lower applied stress level. From a study of the residual stress distribution near the edge of the hole, it was found that the experimental residual compressive stresses in absolute values were much less than the calculated values derived by previous analytical methods. Thus, a simplified residual stress model for describing the FCG behavior at coldworked fastener holes is proposed, from which, the Delta-K(eff) and fatigue lives of specimens after cold-expansion can be predicted satisfactorily for engineering applications. Author

**A86-40619**

### STRUCTURAL MATERIALS IN AERONAUTICS. II - PROSPECTS AND PERSPECTIVES

G. G. POPE (Royal Aircraft Establishment, Farnborough, England) Aerospace (UK) (ISSN 0305-0831), vol. 13, May-June 1986, p. 22-30. refs

Materials designed for airframe and gas turbine applications are presented, and it is noted that for the former category, the UK has the following alloys in mind: (1) a medium strength alloy DTDXXXA, intended to replace the medium strength general purpose alloy 2014-T651; (2) a high strength alloy DTDXXXB to replace higher strength 7000 series alloys; and (3) a fatigue resistant alloy DTDXXXC to replace 2024-T351. In the area of gas turbine applications, nickel-based alloys reinforced with tungsten wires have been made as well as ceramic materials such as those derived from the Si-Al-O-N system, and a composite made of carbon fibers in a carbon matrix. It is concluded that both the properties and the cost of an aircraft component are determined as much by the manufacturing route as by the intrinsic properties and cost of the material. Moreover, these areas require continued attention if the major potential benefits (i.e., cost effectiveness) of current advances in materials technology are to be realized to the full. K.K.

**A86-41051**

### COMPOSITE MATERIALS: TESTING AND DESIGN; PROCEEDINGS OF THE SEVENTH CONFERENCE, PHILADELPHIA, PA, APRIL 2-4, 1984

J. M. WHITNEY, ED. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Conference sponsored by ASTM. Philadelphia, PA, American Society for Testing and Materials, 1986, 466 p. For individual items see A86-41052 to A86-41073.

The present conference on the current development state of composite materials ranges over structures, failure mechanisms, delamination characteristics, strength properties, and analysis and characterization methods. Attention is given to the effects of manufacturing defects and service-induced damage on strength, testing and analysis methods for graphite/epoxy filament-wound composites' fracture toughness, the effect of stress biaxiality on transverse tensile strain-to-failure, the effect of laminate stacking sequence on notch sensitivity, and the effect of impact and fatigue loads on the strength of graphite/epoxy composites. Also considered are delamination-resistant composite concepts, the stimulation of delamination by interlaminar shear, and the tensile strength and modulus of a three-dimensional braided composite. O.C.

**A86-41052**

### BOLTED COMPOSITE REPAIRS SUBJECTED TO BIAXIAL OR SHEAR LOADS

R. E. BOHLMANN, G. D. RENIERI, and B. L. RILEY (McDonnell Aircraft Co; Saint Louis, MO) IN: Composite materials: Testing and design; Proceedings of the Seventh Conference, Philadelphia, PA, April 2-4, 1984. Philadelphia, PA, American Society for Testing and Materials, 1986, p. 34-47. refs
(Contract N62269-81-C-0297)

The methodology to analyze bolted composite repairs subjected to biaxial or shear loads was developed. The methodology was incorporated into an existing McDonnell Aircraft Company (MCAIR) interactive computer program, BREPAIR, which was initially developed for uniaxial loading. The analysis determines bolt loads while accounting for hole clearances and determines patch and laminate strains for doubly symmetric finite regions where the damage is represented as a circular cutout. The analysis was verified by comparing predicted results to industry-recognized solutions for laminates containing circular holes (unrepaired), and to test results of an unrepaired and repaired shear panel. Results of this investigation verified that the methodology developed was a viable analytical tool for determining bolted repair designs for damaged laminates subjected to biaxial or shear loads. Author

**A86-41053**

### CHARACTERIZATION OF T300/V-378A GRAPHITE/BISMALEIMIDE FOR STRUCTURAL APPLICATIONS APPLICATIONS

R. L. RAMKUMAR, G. C. GRIMES, and S. J. KONG (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Composite materials: Testing and design; Proceedings of the Seventh Conference, Philadelphia, PA, April 2-4, 1984. Philadelphia, PA, American Society for Testing and Materials, 1986, p. 48-63. Navy-sponsored research. refs

In the present evaluation of T300/V-378A graphite fiber/bismaleimide matrix composites in aircraft structures exposed to service temperatures in the 120-204 C range, the microstructure of cured laminates was examined in order to detect the presence of any process-induced defects, followed by moisture absorption studies and static testing of basic properties. Tests were also conducted on loaded and unloaded hole specimens under room-temperature-dry (RTD) and elevated-temperature-wet (ETW) conditions; impact damage tolerance was tested by measuring hard object impact energy levels. Multibay hat-stiffened flat shear panels were fabricated and subjected to pure-shear static and fatigue tests under RTD and ETW conditions. The data obtained were compared with graphite/epoxy laminate data, which indicated that V-378A bismaleimide is a viable alternative to epoxy matrices in ETW conditions. O.C.

**A86-41684**

### COMPOSITE REPAIR TECHNIQUES EXAMINED

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, May 1986, p. 20-24.

Techniques for repairing composite structure damage caused by surface impact damage, surface thermal blisters, internal voids, and delamination are studied. Visual inspections, tapping tests, ultrasonic inspection systems, and optical micrometers are utilized to locate and identify composite damage. Zone charts which explain the materials to be used in each section of the structure, indicate permissible repairs, and outline repair procedures are employed as the guidelines for damage repair. Various repair techniques such as prepreg or precured patches and epoxy injection are examined; the procedures for patching and the wet-layup process are described. Post-failure analysis using optical and scanning electron microscopy is discussed. I.F.

**A86-41685**
**THERMOPLASTIC COMPOSITES - DESIGN MATERIAL OF THE 1990S?**
D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, May 1986, p. 36-44.

The characteristics and uses of thermoplastic resins are discussed. The properties of thermoplastic resins are compared to thermoset resins and metals. It is observed that thermoplastic resins soften when heated and harden when cooled, their molecular structure remains linear before and after heating and cooling, they have increased temperature resistance, higher melting points, and are resistant to the solvents, fuels and oils used in the aerospace industry. The thermoplastic resins are manufactured by molding, filament winding, and pultrusion; the use of these techniques to produce aircraft components is examined. The properties of various resins applicable for use in advanced high-performance thermoplastic composites and the aircraft cabin interiors are described. The utilization of high-performance thermoplastic composites in the future ATF and the stealth bomber is proposed. I.F.

**A86-41988**
**INFLUENCE OF MOLYBDENUM, TUNGSTEN, AND COBALT ON THE CORROSION OF HIGH-TEMPERATURE STRENGTH NICKEL ALLOYS IN MOLTEN SALTS**
I. V. ORYSHICH and O. S. KOSTYRKO (AN USSR, Institut Problem Lit'ia, Kiev, Ukrainian SSR) (Metallovedenie i Termicheskaia Obrabotka Metallov, Oct. 1985, p. 21-25) Metal Science and Heat Treatment (ISSN 0026-0673), vol. 27, no. 9-10, March 1986, p. 740-746. Translation. refs

Specimens of ZhS6K, EP539, and EP958 high-temperature nickel alloys, which are commonly used in gas turbine, were tested for sulfide and chloride corrosion in molten salts based on sodium sulfate and sodium chloride. It is found that the addition of molybdenum, tungsten, and cobalt increases the resistance of the nickel alloys to sulfide corrosion but decreases their resistance to chloride corrosion. It is also shown that the amounts of molybdenum and tungsten required for maximum resistance to sulfide corrosion depend on the Cr content of the alloys. V.L.

**A86-42424**
**NEW ALLOYS FROM THE QUANTUM ENGINEER**
D. PETTIFOR New Scientist (ISSN 0028-6664), vol. 110, May 29, 1986, p. 48-51.

The contribution quantum mechanics is making to the design of aerospace alloys is described. The strength of the intermetallic particles in an Al matrix determines the properties of the alloy as a whole. The goal is to predict which intermetallic compounds will form and their properties. Quantum mechanics, in the form of Schoedinger's equation, allows predicting the structure and mechanical properties of an intermetallic. Recent data have shown that the average number of valence electrons per atom controls the formation of face-centered or body-centered lattices. Other factors are the differences in size and the electronegativity of the combined atoms. Studies have also revealed a dependency of the mechanical properties on the quantum mechanical bond energy and none on the ionic binding energy. Finally, techniques are outlined for using quantum mechanics to predict the properties and existence of ternary phases. M.S.K.

**A86-42610*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**EFFECT OF SILANE CONCENTRATION ON THE SUPERSONIC COMBUSTION OF A SILANE/METHANE MIXTURE**
G. B. NORTHAM, A. G. MCLAIN, G. L. PELLETT (NASA, Langley Research Center, Hampton, VA), and G. S. DISKIN (Vigyan Research Associates, Inc., Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1396)

A series of direct connect combustor tests was conducted to determine the effect of silane concentration on the supersonic combustion characteristics of silane/methane mixtures. Shock tube ignition delay data indicated more than an order of magnitude reduction in ignition delay times for both 10 and 20 percent silane/methane mixtures as compared to methane. The ignition delay time of the 10 percent mixture was only a factor of 2.3 greater than that of the 20 percent mixture. Supersonic combustion tests were conducted with the fuel injected into a model scramjet combustor. The combustor was mounted at the exit of a Mach 2 nozzle and a hydrogen fired heater was used to provide a variation in test gas total temperature. Tests using the 20 percent silane/methane mixture indicated considerable combustion enhancement when compared to methane alone. This mixture had an autoignition total temperature of 1650 R. This autoignition temperature can be contrasted with 2330 R for hydrogen and 1350 R for a 20 percent silane/hydrogen mixture in similar hardware. Methane without the silane additive did not autoignite in this configuration at total temperatures as high as 3900 R, the maximum temperature at which tests were conducted. Supersonic combustion tests with the silane concentration reduced to 10 percent indicated little improvement in combustion performance over pure methane. The addition of 20 percent silane to methane resulted in a pyrophoric fuel with good supersonic combustion performance. Reducing the silane concentration below this level, however, yielded a less pyrophoric fuel that exhibited poor supersonic combustion performance. Author

**A86-42665*#** National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
**NEW VISTAS IN THE DETERMINATION OF HYDROGEN IN AEROSPACE ENGINE METAL ALLOYS**
M. D. DANFORD (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p. refs
(AIAA PAPER 86-1479)

The application of diffusion theory to the analysis of hydrogen desorption data has been studied. From these analyses, important information concerning hydrogen solubilities and the nature of the hydrogen distributions in the metal has been obtained. Two nickel base alloys, Rene' 41 and Waspaloy, and one ferrous alloy, 4340 steel, were studied in this work. For the nickel base alloys, it was found that the hydrogen distributions after electrolytic charging conformed closely to those which would be predicted by diffusion theory. The hydrogen distributions in electrolytically charged 4340 steel, on the other hand, were essentially uniform in nature, which would not be predicted by diffusion theory. Finally, it has been found that the hydrogen desorption is completely explained by the nature of the hydrogen distribution in the metal, and that the 'fast' hydrogen is not due to surface and subsurface hydride formation, as was originally proposed. Author

**A86-42712*#** Material Concepts, Inc., Columbus, Ohio.
**ADVANCED ROTARY ENGINE COMPONENTS UTILIZING FIBER REINFORCED MG CASTINGS**
D. GODDARD, W. WHITMAN, R. PUMPHREY (Material Concepts, Inc., Columbus, OH), and C.-M. LEE AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1559)

Under a two-phase program sponsored by NASA, the technology for producing advanced rotary engine components utilizing graphite fiber-reinforced magnesium alloy casting is being developed. In Phase I, the successful casting of a simulated intermediate housing was demonstrated. In Phase II, the goal is to produce an operating rotor housing. The effort involves generation of a material property data base, optimization of parameters, and development of wear- and corrosion-resistant cast surfaces and surface coatings. Results to date are described. Author

**A86-43134**
**PROTECTIVE COATING SYSTEMS FOR HIGH-TEMPERATURE GAS TURBINE COMPONENTS; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, NOVEMBER 13, 14, 1984**
Conference sponsored by the Royal Society. Materials Science and Technology (ISSN 0267-0836), vol. 2, March 1986, 144 p. For individual items see A86-43135 to A86-43150.

Papers are presented on pack cementation processes, plasma spray coating processes, physical vapor deposition processes, quality control of high-temperature protective coatings, and the effect of environment on mechanical properties of coated superalloys and gas turbine blades. Also considered are structural stability of coatings, coating-substrate interactions, properties of thermal barrier coatings, laboratory tests for hot-corrosion studies, and correlation between laboratory corrosion rig testing and service experience. Other topics include the use of protective coatings in gas turbine engines, marine applications, coating service experience with industrial gas turbines, and the future direction of research on high-temperature coatings. Papers are also presented on protection against hot corrosion in marine gas turbines, evaluation of additive effects on hot corrosion of Ni-Cr and Co-Cr alloys, and coating/substrate interfaces in Ni-Cr-Al systems. R.R.

**A86-43147**
**USE OF PROTECTIVE COATINGS IN AERO GAS TURBINE ENGINES**
G. W. MEETHAM (Rolls-Royce, Ltd., Derby, England) (Royal Society, Conference on Protective Coating Systems for High-Temperature Gas Turbine Components, London, England, Nov. 13, 14, 1984) Materials Science and Technology (ISSN 0267-0836), vol. 2, March 1986, p. 290-294. refs

Protective coatings used in gas turbine engine turbine and combustion sections are reviewed, and coating selection factors for turbine rotor blade applications, service experience, and the influence of the blade operating environment, are discussed. Aluminide coatings, the most widely used, are inadequate in the most extreme temperature, corrosion and mechanical environments, and improved coatings such as MCrAlY and platinum aluminide coats are considered. Increased component life has been found in using thermal barrier coats for combustion liners, and the recent application of thermal barrier coats to stator vane platforms has necessitated the development of improved bond coats and ceramic overlays. Thermal barrier and corrosion resistant coating choice considerations are cost effectiveness and application specificity. R.R.

**A86-43329#**
**COMPOSITE REPAIR AT THE NAVAL AIR REWORK FACILITY, NORTH ISLAND**
B. L. HALLOCK (U.S. Navy, Naval Air Rework Facility, San Diego, CA) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 6 p. refs
(AIAA PAPER 86-1140)

This paper describes the methodology used to inspect, assess, and repair advanced composite components on Naval aircraft at the Naval Air Rework Facility, North Island. Future considerations for advanced composite repair and maintenance are also addressed. To repair a damaged advanced composite component requires a sequence of events: inspection, assessment, damage removal repair design, repair manufacture, repair installation, and finally repair verification. To date, honeycomb bonded advanced composite skins and monolithic skins have been repaired by the Rework Facility. The advanced composite repair program is expanding as more composite structured aircraft enter the fleet. As new development within the composite field lead to new applications, maintenance/supportability should be a major consideration. Well planned support is an essential part to the success of an aircraft program. Author

**A86-43420**
**EFFECT OF DIFFERENT HYDROGEN-INJECTION TECHNIQUES ON ITS BURNUP IN A SUPERSONIC AIR FLOW [VLIIANIE RAZLICHNYKH SPOSOBOV PODACHI VODORODA NA EGO VYGORANIE V SVERKHZVUKOVOM POTOKE VOZDUKHA]**
V. A. ZABAIKIN and A. M. LAZAREV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), March 1986, p. 44-49. In Russian. refs

The technique used to inject a gaseous fuel into a supersonic oxidizer flow has an important effect on flow pressure losses, flame stabilization, and combustion efficiency during supersonic combustion. In the present study, an experiment was conducted to measure hydrogen combustion efficiency for different injection techniques at a temperature of the supersonic air flow above 1000 K. Three types of injectors were considered: straight-flow, vortex-type, and a device yielding a fan of perpendicular jets. The data confirm the decisive role of the injection method and the wave structure of the jets on combustion efficiency in a hydrogen flame. B.J.

**N86-28131*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**LIGHT WEIGHT FIRE RESISTANT GRAPHITE COMPOSITES Patent**
D. A. KOURTIDES, J. A. PARKER, and M. T. S. HSU 1 Jul. 1986 12 p Filed 28 Feb. 1985 Supersedes N85-28976 (23 - 18, p 3068)
(NASA-CLASS-ARC-11615-1SB; US-PATENT-4,598,007; US-PATENT-APPL-SN-706682; US-PATENT-CLASS-428-116; US-PATENT-CLASS-428-408; US-PATENT-CLASS-428-921; US-PATENT-CLASS-526-265) Avail: US Patent and Trademark Office CSCL 11D

Composite structures with a honeycomb core and characterized by lightweight and excellent fire resistance are provided. These sandwich structures employ facesheets made up of bismaleimide-vinyl styrylpyridine copolymers with fiber reinforcement such as carbon fiber reinforcement. In preferred embodiments the facesheets are over layered with a decorative film. The properties of these composites make them attractive materials of construction aircraft and spacecraft. NASA

**N86-28133#** Construcciones Aeronauticas S.A., Madrid (Spain).
**CHEMICAL CONTROL FOR AIRBUS COMPOSITES. HPLC STANDARDIZATION**
J. SANCHEZ and E. GARATE 20 Dec. 1984 141 p
(I-104/84; ESA-86-97060) Avail: NTIS HC A07/MF A01

Liquid chromatography with a UV detector to assess resins used in the Airbus was tested on two resins. Results show that the chromatographic method permits an adequate separation of the different components of both resins, though the fact of having to perform a gradient limits the integration accuracy of the different peaks and therefore supposes a limitation of the method. None of the two wavelengths used (220 and 230 nm) seems to have any influence on the accuracy of the results obtained. ESA

**N86-28168#** Avco-Everett Research Lab., Mass.
**LASER METALWORKING TECHNOLOGY TRANSFER Final Report**
O. A. SANDVEN 1986 84 p
(Contract N00014-82-C-2373)
(AD-A165808) Avail: NTIS HC A05/MF A01 CSCL 11F

The Technology Transfer program assists in the utilization and integration of the laser facility in the manufacturing of naval ordnance components and systems. This assistance consists of targeting workpieces and production steps suitable for laser processing in terms of cost effectiveness and quality enhancement, the development of techniques and procedures for such processing and the establishment of processing parameters and other pertinent data. The work is related to laser surface transformation hardening of steels. The response of a number of frequently used steels to such laser processing has been determined over a wide range of processing parameters. Models and calculator programs for the prediction of laser hardening have been developed and tested, and the necessary thermophysical constants of the various materials determined by statistical and empirical means. In addition to the transformation hardening survey, process development work relating to the laser hardfacing of aircraft carrier catapult rails has been performed, and preliminary techniques and processing data established for different combinations of hardfacing alloys/substrate materials. GRA

**N86-28186#** National Bureau of Standards, Gaithersburg, Md.
**MATERIALS TECHNOLOGY FOR ELECTRICAL APPLIANCES: MAGNETIC AND ELECTRICAL PROPERTIES OF METALS AND ALLOYS**
G. N. DUBININ and Y. S. AVRAAMOV 1985 277 p Transl. into ENGLISH of the mono. "Konstruktsionnye, Provodnikove i Magnitnye Materialy (Elektromaterialovedenie)" Moscow, USSR, Mashinostroenie, 1973 p 1-268 Sponsored by NSF
(PB86-184314; TT-79-52021) Avail: NTIS HC A13/MF A01
CSCL 11F

Described are the theoretical principles of the materials technology for electrical appliances used in aviation instrumentation. Major attention has been paid to the structure and properties of metals and alloys used in modern aviation instrumentation. The authors have elaborated the relationship between the structure and physiochemical properties of alloys. Various methods of developing special properties in alloys have been described. A considerable part of the book has been devoted to the study of special-purpose alloys such as soft and hard magnetic materials, ferrites, alloys with special thermal and electrical properties, and semiconductors. Students in aviation institutes will find the book very useful. Aviation, electrical and mechanical engineers engaged in the development of electrical appliances will also benefit from the book. GRA

**N86-28193** National Physical Lab., Teddington (England). Div. of Materials Applications.
**CHARACTERISATION AND INFLUENCE OF ORIENTATION AND INTERNAL STRESS IN ACRYLIC AIRCRAFT MATERIALS Final Report**
B. E. READ, G. D. DEAN, and J. C. DUNCAN Dec. 1985 79 p
(Contract MOD-RAE(F)MT-69/2/10)
(NPL-DMA(A)113; ISSN-0143-7313; ESA-86-97132) Avail: Issuing Activity

A photoelastic method for characterizing the internal stresses in crosslinked PMMA acrylic aircraft materials and windows was developed. The time-dependence of optical birefringence during creep or relaxation tests at different temperatures suggests that three nonequilibrium internal stress components operate: stress characteristic of the molecular orientation produced by stretching at high temperature; a glasslike distortional stress; and a stress arising from molecular conformational changes generated by the beta relaxation process in PMMA. A light-scattering technique was used to characterize internal stresses from temperature-dependent birefringence measurements in biaxially oriented materials. Levels of molecular orientation in biaxially stretched sheets and windows correspond to an orientational stress of 2 + or - 0.2 MPa along each of the stretching directions. Internal stresses in the crosslinked acrylic materials can be assessed from surface acoustic wave velocity. ESA

**N86-28236#** University of Southern California, Los Angeles.
**A NOVEL FEEDBACK CONCEPT FOR COMBUSTION INSTABILITY IN RAMJETS**
P. R. CHOUDHURY, M. GERSTEIN, and R. MOJARADI *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 279-287 Oct. 1985
(Contract AF-AFOSR-0222-82)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Many dump combustors exhibit low frequency longitudinal combustion instability in the frequency range of 80 to 300 Hz. Although the exact causes of combustion instability are not known precisely, it is generally accepted that the interaction of the shock induced pressure pulsation and the coherent vortex shedding at the dump plane induces combustion instability. When the coherence of the shear layer at the dump plane is disrupted either by gasjets or by upstream protrusions the effect of combustion instability is found to be minimized. The control system suggested here is based upon the idea of disrupting the shear layer at the dump plane by means of pulsing gasjets. The control system senses the critical combination of frequency, amplitude and phase angle upstream of the combustor and actuates the gasjets at the dump plane at an appropriate combination of frequency, amplitude and phase angle to partially negate the effect of upstream pressure pulsation. Experiments in two laboratory scale two-dimensional (6.4 cm x 3.8 cm and 7.6 cm x 2.54 cm) dump combustors using premixed propane-air mixtures show the feasibility of reducing chamber pressure amplitude by such a technique. Author

**N86-29028#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Mechanical Behavior of Materials Lab.
**CRACK GROWTH IN TITANIUM ALLOYS UNDER THE CONJOINT ACTION OF HIGH AND LOW CYCLE FATIGUE Final Report, 15 Jun. 1983 - 14 Jun. 1985**
B. E. POWELL and I. HENDERSON Feb. 1986 77 p
(Contract F49620-83-C-0116)
(AD-A166429; AFWAL-TR-85-4093) Avail: NTIS HC A05/MF A01 CSCL 11F

Fatigue crack propagation rates have been measured for two titanium-based aeroengine disc alloys using compact tension test pieces. The loading block employed simulates two features of the engine flight pattern. A major stress cycle represents the start-stop operation which leads to low cycle fatigue. In-flight vibrations, which may give rise to high cycle fatigue, are represented by superimposed minor cycles of high frequency. With a lifting policy of retirement for cause the useful lives of blades and discs are limited by the onset of minor cycle crack growth. The threshold values associated with the minor cycles have been used to predict this event. Similarly the method of linear summation has been used to predict the subsequent fatigue crack growth rates. These predictions are successful for Ti-6A1-4V, whilst for Ti-5331S they are found to be either accurate or safe. Although Ti-5331S displays a marginally greater resistance to the onset of minor cycle crack growth, of greater significance is its reduced crack growth rates prior to this event. As a consequence components fabricated from Ti-5331S will exhibit longer fatigue crack propagation lives when subjected to the conjoint action of high and low cycle fatigue. GRA

**N86-29037#** Societe Nationale Industrielle Aerospatiale, Paris (France).
**THE FUTURE OF SURFACE TREATMENTS IN AERONAUTICAL CONSTRUCTION [L'AVENIR DES TRAITEMENTS DE SURFACE EN CONSTRUCTION AERONAUTIQUE]**
G. SERTOUR 29 Oct. 1985 8 p In FRENCH
(SNIAS-861-551-101; DCQ-1/85; ESA-86-97176) Avail: NTIS HC A02/MF A01

Surface treatments employed in the aeronautical industry and their evolution trends are presented. Aluminum or titanium alloy protection by electrolytic deposits, anodization, and vacuum or plasma deposits; the surface treatment of composite materials by paint or metallization; and the corrosion protection of refractory alloys by vapor phase diffusion of aluminum or chrome are considered. Fretting corrosion is shown to remain an unsolved problem related to several degradation and fatigue phenomena. ESA

**N86-29039*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PROCESS FOR PREPARING ESSENTIALLY COLORLESS POLYIMIDE FILM CONTAINING PHENOXY-LINKED DIAMINES Patent**

A. K. STCLAIR and T. L. STCLAIR 17 Jun. 1986 8 p Filed 23 Aug. 1984 Supersedes N85-20128 (23 - 11, p 1611)
(NASA-CASE-LAR-13353-1; US-PATENT-4,595,548; US-PATENT-APPL-SN-643524; US-PATENT-CLASS-264-236; US-PATENT-CLASS-264-204; US-PATENT-CLASS-264-216; US-PATENT-CLASS-264-347; US-PATENT-CLASS-528-222; US-PATENT-CLASS-528-341; US-PATENT-CLASS-528-183)
Avail: US Patent and Trademark Office CSCL 11C

A polyimide film that is approximately 90% transparent at 500 nm, useful for thermal protective coatings and solar cells, and the processes for preparing the same by thermal and chemical conversion are disclosed. An essential feature for achieving maximum optical transparency films requires utilizing recrystallized and/or sublimated specific aromatic diamines and dianhydride monomers and introducing phenoxy or thiophenyl separator groups and isomeric m,m' or o,p'-oriented diamines into the polymer molecular structure. The incorporation of these groups in the polymer structure serves to separate the chromaphoric centers and reduce the formation of inter-chain and intra-chain charge transfer complexes which normally cause absorptions in the UV-visible range. The films may be obtained by hand, brushing, casting, or spraying a layer of polyamic acid solutions onto a surface and thermally converting the applied layer to the polyimide, or the polyamic acid solution can be chemically converted to the polyimide, subsequentially dissolved in an organic solvent, and applied as a polyimide film layer with the solvent therein thermally removed. Author

**N86-29242#** Boeing Vertol Co., Philadelphia, Pa.

**A STUDY OF THE POTENTIAL BENEFITS ASSOCIATED WITH THE DEVELOPMENT OF A DEDICATED HELICOPTER TRANSMISSION LUBRICANT**

R. J. DRAGO, P. J. MANGIONE (Naval Air Propulsion Test Center, Trenton, N.J.), and R. D. WENDRZYCKI *In* AGARD Aircraft and Bearing Tribological Systems 11 p Feb. 1986
Avail: NTIS HC A11/MF A01

A common oil is now used in both the engines and transmissions of virtually all U.S military helicopters. While this provides significant logistic advantages, these advantages are attained only by compromising the optimization of the oil for either system. The results of two studies undertaken to determine what benefits would accure through the development of a special oil tailored specifically to meet the unique requirements of high-speed, heavily loaded helicopter transmission systems are summarized. These studies, conducted independently by two major helicopter manufacturers under the direction of the Naval Air Propulsion Center, addressed specific problem areas as related to typical production aircraft in order to reach well-documented conclusions. In addition, the effect of the availability of such a special gearbox lubricant on the development of other advanced-technology components was evaluated and documented. Author

**N86-29244#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

**REQUIREMENTS ON LUBRICATION OIL FROM THE VIEW OF A HELICOPTER MANUFACTURER**

J. HARTMANN and W. JONDA *In* AGARD Aircraft and Bearing Tribological Systems 6 p Feb. 1986
Avail NTIS HC A11/MF A01

Experience with known oil types, used in helicopters for transmissions, engines, hydraulics and brakes has shown that 3 main conditions if available, would improve drastically the performance of the aircraft. These 3 main conditions are: the same type of oil should be usable for all the above mentioned systems; the oils brands, produced according to a common specification, but by different manufacturers, should be mixable without restrictions; and some features of the oil, which are specially important for helicopter operations, should be improved. Author

**N86-29245#** Army Materials and Mechanics Research Center, Watertown, Mass. Physical Metallurgy Branch.

**DIRECTION OF R AND D AND CURRENT STATUS OF UNDERSTANDING OF ADVANCED GEAR STEELS**

P. J. FOPIANO, J. E. KRZANOWSKI, and G. M. CRAWFORD *In* AGARD Aircraft and Bearing Tribological Systems 15 p Feb. 1986
Avail NTIS HC A11/MF A01

High performance gears in the modern helicopter must operate at ever increasing torque and RPM. A major consequence of this increased torque and RPM is a significant increase in the surface temperature and increased scuffing of the gears. In response to this problem, Boeing-Vertol introduced a new class of steel (hot work tool steel) as a high performance aircraft gear steel and started a trend which all subsequent work has confirmed to be a correct decision. The three most prominent candidate critical high temperature aircraft gear steels including Vasco X-2M, CARTECH X-53 (PYROWEAR 53), and CBS600 are discussed. The heat treatment responses of these alloys will be compared. Three additional alloys (M50NiL, CBS1000M, and AMAX B) are discussed in less detail. Author

**N86-29249#** Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

**MILITARY AIRCRAFT PROPULSION LUBRICANTS: CURRENT AND FUTURE TRENDS**

G. A. BEANE, IV, L. J. GSCHWENDER, C. E. SNYDER, JR., and J. T. SHIMSKI (Naval Air Propulsion Test Center, Trenton, N.J.) *In* AGARD Aircraft and Bearing Tribological Systems 16 p Feb. 1986
Avail: NTIS HC A11/MF A01

An assessment of the performance of MIL-L-7808J and MIL-L-23699C Military Specification lubricating oils in turbine engines and helicopter gear boxes is presented along with predicted performance of current and upgraded military specification oils in advanced and growth engine designs. Data is presented on advanced ester base engine lubricants, corrosion inhibited engine oils, and separate helicopter gear box oils evolving from current developmental research efforts. Future high temperature candidate fluids representing the ultimate stability for turbine engine oils are also discussed. Their use, in most cases, entails engine design considerations to accommodate their unique properties. The advantages and disadvantages of the various classes of synthetic lubricants for turbine engine applications are discussed, and deficiencies are identified where additional research programs are needed. Author

**N86-29250#** Imperial Coll. of Science and Technology, London (England).

**FUTURE TRENDS IN HELICOPTER TRANSMISSION LUBRICANTS**

H. A. SPIKES *In* AGARD Aircraft and Bearing Tribological Systems 10 p Feb. 1986
Avail: NTIS HC A11/MF A01

Some recent fundamental studies relating to the lubrication of helicopter transmissions are presented, as well as implications for future oil development. The resulting enhanced understanding of lubrication mechanisms has shown that real potential exists both for improved performance and for the ability to cater to higher temperatures, by means of the formulation and use of improved transmission oils. If such benefits are recognized and if the new knowledge is correctly applied, there is no reason why helicopter gearbox reliability should not be appreciably improved by the end of the decade. Author

**N86-29251#** Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
**AIRCRAFT ENGINE OILS AND THEIR BEHAVIOUR AT HIGH TEMPERATURES**
K. MAIER *In* AGARD Aircraft and Bearing Tribological Systems 12 p Feb. 1986
Avail: NTIS HC A11/MF A01

Characteristics of aero-engine oils are changed considerably under high-temperature conditions ( 200 to 250 C). Consequences of this are the formation of aging products and deposits, deficiences in the tribological behavior and spontaneous ignition, in extreme cases. The problems arising from these are illustrated using several selected examples, and their effects on engine functioning are described. Author

**N86-29253#** Technische Univ., Munich (West Germany).
**SCORING TESTS OF AIRCRAFT TRANSMISSION LUBRICANTS AT HIGH SPEEDS AND HIGH TEMPERATURES**
H. WINTER and K. MICHAELIS *In* AGARD Aircraft and Bearing Tribological Systems 9 p Feb. 1986
Avail: NTIS HC A11/MF A01

Aircraft engines always contain gears that have to be lubricated under conditions of high speeds and extremely high temperatures. In this field of application scoring damage is likely to occur. In Europe and partly also in the USA the scoring load capacity of gear oils is expressed in terms of FZG Scoring Load Stage. The FZG Gear Test Rig is described. The normal test procedure A/8.3/90 as standardized in DIN 51 354 using A-type gears at a pitch line velocity of $v = 8.3$ m/s and a starting oil temperature of 90 C is presented. A modified procedure at double speed and increased oil temperature A/16.6/140 is discussed. Because of the high costs and problems with the availability of test gears a modified FZG Ryder Test was developed. The method is presented and comparative results of typical aircraft engine oils in the FZG, the FZG-Ryder and the original Ryder Gear Test are shown. From this experience it becomes obvious that alternative test methods for the evaluation of scoring load capacity of aircraft transmission lubricants can be available in the near future. Author

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## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-40109#**
**OPTIMAL DESIGN OF ANTISYMMETRIC LAMINATED COMPOSITE PLATES**
N. G. R. IYENGAR (Arizona, University, Tucson) and S. P. JOSHI (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 673-678) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 359, 360. Previously cited in issue 13, p. 1896, Accession no. A85-30299. refs

**A86-40215**
**INCOHERENT IMAGING OF RADAR TARGETS**
A. VAN OMMEN and G. A. VAN DER SPEK (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Physisch Laboratorium TNO, The Hague, Netherlands) Electronics Letters (ISSN 0013-5194), vol. 22, May 8, 1986, p. 548-550.

Theory suggests that, if a target can be modeled as a rigid constellation of point scatterers, the RCS pattern over a certain aspect change can be used to produce a one-dimensional image. The results for actual measured RCS patterns, however, are not promising. This is illustrated by processing on 4 s of echo data obtained from a Boeing 737 in straight flight, during which its aspect change is 2 deg. The conclusion might be that, for the application considered, aircraft cannot be modeled as a rigid constellation of point scatterers; this is partly due to the treatment of a three-dimensional target as a line target. B.J.

**A86-40344*** Vrije Universiteit, Brussels (Belgium).
**THE COMBINED EFFECTS OF STRESS AND MOISTURE ON THE STRUCTURAL INTEGRITY OF COMPOSITES**
C. HIEL, A. CARDON (Brussel, Vrije Universiteit, Brussels, Belgium), M. ADAMSON, and H. NELSON (NASA, Ames Research Center, Moffett Field, CA) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 193-200. refs

A variational approach is used to model the moisture content and distribution profiles which cause swelling in polymers and composites which are used as aircraft structural components. The moisture intrusion stems from humidity, which makes the problem one of diffusion of mass from the environment into a semiinfinite plate with a given diffusion coefficient and thickness. Lagrangian, ordinary differential equations are defined for the mass diffusion, including driving force, mass potential and volume dissipation expressions. Account is taken of the effects of stress on diffusivity, including the dilatational stress caused by inhomogeneous swelling of the material. It is noted that material near the top and bottom of a part undergoes the most swelling, and the evolution of moisture diffusion in the materials is traced. Finally, experimental data are used to define differential equations for predicting the final moisture distribution within the material. M.S.K.

**A86-40353**
**FAILURE ANALYSIS OF COMPOSITE ANGLE STRUCTURES**
C.-T. SUN and S.-R. KELLY (Purdue University, West Lafayette, IN) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 277-284. Research supported by the Boeing Aircraft Co.

Angle spars of laminated composites are analyzed using the finite element method. The resulting stresses are compared with the homogeneous and isotropic curved beam solution. Similarity of these solutions is noted. Failure criteria are evaluated based on existing experimental results. It is found that both interlaminar normal stress and bending stress in the curved section are responsible for causing delamination and thus total failure of the angle spar. Author

**A86-40361**
**A MODEL FOR THE EQUIVALENT BENDING CHARACTERISTICS OF A COMPOSITE BEAM [CALCUL DES CARACTERISTIQUES EQUIVALENTES DE TORSION POUR UNE POUTRE COMPOSITE]**
J.-J. BARRAU (Ecole Nationale Superieure de l'Aeronautique et de l'Espace, Toulouse, France) and D. GAY (Toulouse III, Universite, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 373-378. In French.

A warping function is employed to obtain the torsional stiffness and the shear center of a composite beam in order to treat a composite helicopter blade with a model for a cylindrical beam applied to a homogeneous material. Equations are defined for the displacement field of the blade under rotation and for equilibrium conditions at the interface between the composite and another material and between the composite and the free surface. Bending forces are only exerted when the system is in equilibrium and always perpendicular to the blade. The bending stiffness is obtained by integration of the moments exerted by the tangential stresses. A finite element method is then introduced for numerical solution of the beam under bending stress. Techniques for accelerating the convergence using either triagonal or one-dimensional elements in the computations are discussed. A sample problem is worked out for a carbon composite blade, showing that the model provides results within the bounds of experimental uncertainty. M.S.K.

**A86-40403**

### SPECKLE EFFECTS ON COHERENT LASER RADAR DETECTION EFFICIENCY

J. C. LEADER (McDonnell Douglas Research Laboratories, Saint Louis, MO) Optical Engineering (ISSN 0091-3286), vol. 25, May 1986, p. 644-650. Research supported by the McDonnell Douglas Independent Research and Development Program. refs
(Contract N60921-79-C-0180)

Equations for laser radar heterodyne efficiency are derived by assuming that heterodyne detection is degraded by phase-front distortion produced by target speckle and atmospheric turbulence. These equations are numerically evaluated for representative target detection scenarios to illustrate the effects of laser speckle on coherent laser radar detection. Author

**A86-40495**

### AUTOCLAVE, COMPRESSION MOULDING

K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 149-158.

Autoclave and compression molding are well-known technologies in use for the fabrication of fiber composite structures. This paper presents data gathered with autoclave curing of extremely thin, high modulus carbon fiber-composite (CFC) face skins for space structures, autoclave-curing of thickness tapered high tensile CFC skin of an aircraft taileron, press curing of thick high tensile strength CFC rotor hub components, and the use of an oven for vacuum bag curing. Author

**A86-40509**

### ROBOTIC NONDESTRUCTIVE INSPECTION OF AEROSPACE STRUCTURES

G. L. WORKMAN and W. TEOH (Alabama, University, Huntsville) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 4-11 to 4-24.

Nondestructive inspection of critical components and systems used in aerospace structures requires that the inspection system provide a consistent scanning capability to determine structural integrity in a timely and cost-effective manner. The scanning system may be single-ended, as in pulse echo electronics or eddy currents, or double-ended as in through transmission ultrasonics or X-ray applications. Many of the scanning systems developed in the past for automated nondestructive inspection of large structures such as aircraft wings or fuselages usually are designed specifically for that application and can be very expensive. There is no built-in flexibility for scanning other types of structures; hence there is a need for general purpose scanning systems which use the industrial robot as a programmable scanning device. Author

**A86-40527**

### A STUDY OF OPTIMIZING CUTTING TOOL PERFORMANCE IN HIGH TENSILE STRENGTH MATERIALS

J. GIEBLER (Prototyp-Werk GmbH, Zell am Harmersbach, West Germany) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 9-19 to 9-29.

This study shows the influences that different machining variables, in particular feed rates, have on cutting life and surface finish when milling or threading materials such as stainless steel, titanium and Inconel. Optimum machining values are easily determined by measuring the peak-to-valley heights of the surface texture finish. The study evaluates the performance of form threading Inconel 718 and the resulting advantages of such a procedure in practical application. Through the use of computer-aided design, special surface treatments and the application of the proper oils, the forming of Inconel 718 may achieve a high degree of success. Author

**A86-40712#**

### OPTICAL DETERMINATION OF THE EFFECTS OF A MICROMINIATURE ACCELEROMETER ON RESONANCE OF A SMALL AIRFOIL

T. E. MCDEVITT and C. S. VIKRAM (Pennsylvania State University, State College) IN: Fluid measurements and instrumentation forum - 1986; Proceedings of the Fourth Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 11-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 73-75.

An experiment determining the influence of a microminiature accelerometer on the resonance of a small NACA 0015 blade is discussed. Time average holographic interferometry and an optical proximity sensor were used to record the resonance frequency and amplitude of the blade with and without the accelerometer while the blade was excited acoustically. Author

**A86-40720#**

### SAMPLING OF SOLID PARTICLES IN CLOUDS

F. FEUILLEBOIS, A. LASEK, and M.-F. SCIBILIA (CNRS, Laboratoire d'Aerothermique, Meudon, France) IN: Gas-solid flows - 1986; Proceedings of the Fourth Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 11-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 139-144. refs

This paper is concerned with the sampling of small solid particles from clouds by an airborne apparatus to be mounted on an airplane for meteorological investigations. In the airborne experiment the particles entering the test tube should be as representative as possible of the upstream conditions ahead of the plane, in the real cloud. Due to the inertia of the particles, the proportion of the different sizes of particles entering the test tube depends on the location of the tube mouth. A method of calculating the real concentration in particles of different sizes is presented, using the results of measurements executed during the flight of an airplane in a cloud. Two geometries are considered: the nose of the airplane, represented schematically by a hemisphere, and a wing represented by a (2D) Joukowski profile which matches well a NACA 0015 profile on its leading edge. Author

**A86-40733#**

### DILUTE GAS-PARTICLE FLOW IN A CENTRIFUGAL COMPRESSOR IMPELLER

H. LIU and C. MA (Xian Jiaotong University, Xian, People's Republic of China) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 67-73. refs

This paper presents computational results of particle trajectories of a dilute gas-particle flow in a centrifugal compressor impeller. The particle trajectory calculations are based on a three-dimensional gas flow field. Results show that pressure surfaces of blades and the joint regions of the hub and the pressure surfaces at the inlet and the outlet of the blade passage experience severe particle impacts. Considerations are also given to effects of material density and rebound characteristic on the particle motion. Author

**A86-40734#**

### PARTICLE TRAJECTORIES IN FULL 3D FLOW FIELD OF TURBOMACHINERY

Z. G. LING (Shanghai University of Engineering Sciences, People's Republic of China) and S. L. HUANG (Chengdu University of Science and Technology, People's Republic of China) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 75-80. refs

In this paper, particle trajectories in turbine stages are predicted in connection with full 3D gas flow field solved by the time marching method. The secondary flow effect is also partially considered by assuming a total pressure distribution at the inlet of the moving blade row. The results show that passage vortex due to secondary flow will cause upward and downward divergence of particle trajectories at the rear part of near blade pressure surface, evidenced by the real appearance of eroded trace on turbine blade after a long period of operation. Author

**A86-40775**

### DIGITAL SIMULATION OF REGULATED ELECTRICAL POWER SUPPLIES FOR MILITARY APPLICATIONS

V. V. VADHER and I. R. SMITH (Loughborough University of Technology, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 511-516.

The paper presents a generalized model for a regulated generator (for supplying power on board aircraft, military vehicles, or ships) which copes with the combined loading conditions likely to be encountered. The model is described in relation to an m-phase star-connected generator. The use of an additional but simple connection matrix is all that is necessary to enable the corresponding delta-connected machine to be considered. Simulation results are presented. B.J.

**A86-41254**

### LARGE AND SMALL STRUCTURES IN THE COMPUTATION OF TRANSITION TO FULLY DEVELOPED TURBULENT FLOWS

P. PERRIER (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) IN: Macroscopic modelling of turbulent flows; Proceedings of the Workshop, Valbonne, France, December 10-14, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 32-44. refs

How the large structures of turbulent flows have to be modellized, especially from the beginning of their onset, without any hypothesis based on fully developed turbulence, is discussed. A completely mathematical derived model is presented, given by homogenization theory. That model would be able to evaluate the size and behavior of large structures in the presence of statistical equilibrium of small structures. Author

**A86-41261*** Rutgers Univ., New Brunswick, N. J.

### MODELLING OF THREE-DIMENSIONAL SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS

D. D. KNIGHT (Rutgers University, New Brunswick, NJ) IN: Macroscopic modelling of turbulent flows; Proceedings of the Workshop, Valbonne, France, December 10-14, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 177-201. NASA-supported research. refs

(Contract AF-AFOSR-82-0040)

The accuracy of numerical computations of the three-dimensional sharp fin flow field using the Reynolds-averaged Navier-Stokes equations is examined. Computed flows are compared with a set of benchmark experiments at Mach 3 for two different Reynolds numbers. A detailed comparison is performed between experimental data and separate computational results for the three-dimensional sharp fin for a 10 deg fin angle in order to examine the accuracy of two different turbulence models. The computed surface pressure for the fin at a 20 deg angle is compared with recent experimental data. The computed yaw angle profiles are shown to be sensitive to the turbulence model. In the immediate vicinity of the surface, the calculated results using the Baldwin-Lomax (1978) model are in better agreement with the data than the Jones-Launder (1972) model. Within the inner portion of the boundary layer, both models tend to underpredict the yaw angle. C.D.

**A86-41574**

### PROBABILITY OF DETECTION OF FLAWS IN A GAS TURBINE ENGINE COMPONENT USING ELECTRIC CURRENT PERTURBATION

G. L. BURKHARDT and R. E. BEISSNER (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 333-341. USAF-supported research.

The electric-current perturbation technique was used to estimate the probability of detection (POD) of surface flaws in blade slots of a F-100 turbofan first-stage Ti 6-2-4-6 fan disk with the objective of reliable flaw detection. At the retirement-for-cause target flaw size of 0.010-in-long and 0.005-in-deep, EDM slots were used to simulate fatigue cracks. POD as a function of flaw size was estimated from the POD data obtained from experimentally determined probability density functions for background and flaw signals. Depending on the scan track spacing, the POD was found to be close to 100 percent for flaw lengths of about 0.011 to 0.013 in. In parts with background noise lower than that in the F-100 first-stage fan disk blade slots, a higher POD for even smaller flaws can be achieved. I.S.

**A86-41576**

### APPLICATION OF A COMPUTER MODEL TO ELECTRIC CURRENT PERTURBATION PROBE DESIGN

R. E. BEISSNER and G. L. BURKHARDT (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 371-378.

(Contract W-7405-ENG-82)

The use of computer models of electromagnetic NDE probes to aid in probe design and applications is illustrated using examples. The miniaturization of the type of probe being considered which is of the electric current perturbation design, is addressed, considering the flaw responses of alternative configurations and their relevance to the inspection of a certain feature of an F100 engine part. Then, the use of the computer models to help determine the optimum frequency for subsurface flaw detection in the presence of near-surface anomalies that tend to mask the flaw signal is addressed, including the choice of operating frequency and phase shift to maximize the signal-to-noise ratio. C.D.

**A86-41581**

### AUTOMATIC EDDY CURRENT INSPECTION OF ANTIROTATION WINDOWS IN F100 ENGINE COMPRESSOR AIR SEALS

W. HOPPE and D. STUBBS (Systems Research Laboratories, Inc., Dayton, OH) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 463-474.

(Contract F33615-81-C-5002)

A procedure for separating the notch signal detected by a probe from the geometry signal is proposed. A differential pencil probe is utilized to scan an aircraft engine air seal that contains six antirotation windows, three of which contain electrical discharge machine notches. The problems with separating the notch signal from the geometry signal by subtracting the geometry signal from the inspection signal or filtering data using analog digital filters are discussed. The difference between the mean frequencies of the vertical and horizontal components of the impedance plane versus time detected in the notch signal is examined. It is observed that the geometry signal is in both the time and frequency domains. The horizontal and vertical components are calculated and a correlation between the components is obtained. Examples are presented revealing the applicability of this procedure for detecting notch signals based on differences in the vertical and horizontal components of the impedance plane. I.F.

**A86-41582**

### AUTOMATIC EDDY CURRENT HOLE CENTERING FOR AIRCRAFT ENGINE COMPONENTS

D. STUBBS, W. HOPPE, and B. OLDING (Systems Research Laboratories, Inc., Dayton, OH) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 475-481.
(Contract F33615-81-C-5002)

An algorithm for centering a rotating eddy current hole probe over a hole is presented. Results show this algorithm to be fast, accurate, reliable, and flexible for a wide range of probe diameters, with attainable accuracies better than 0.0005 arcsec. Evidence is presented showing the applicability of this algorithm to cases where the probe is off center by more than the probe diameter. Data are also presented which show the ability of the algorithm to compensate for nearby geometries that adversely affect the centering procedure. C.D.

**A86-41596**

### AN ANALYSIS OF ACOUSTIC EMISSION DETECTED DURING FATIGUE TESTING OF AN AIRCRAFT

C. M. SCALA, R. A. COYLE, and S. J. BOWLES (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Review of progress in quantitative nondestructive evaluation. Volume 4B - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 709-718. refs

Preliminary results are presented from an evaluation of the effectiveness of in-flight acoustic emission (AE) monitoring of fatigue cracking in the wing spars of Mirage aircraft. Various types of AE sensors were examined prior to selection of thin-disk and conical sensors to aid in the pattern recognition signal processing. The pattern recognition codes provided the capability of discerning among saturation data, signal rise-time and duration data, time-domain shape factors, and spectral data, and allowed the performance of autocorrelations. Laboratory-scale pretests characterized inclusion fracture signals as opposed to those from gas flow, em interference, mechanical noise, etc. Sensors were then inserted into wing spar fastener holes of two aircraft wings that were monitored in-flight from 1981-82. Data from one wing proved insufficient for distinguishing between the waveforms emitted by inclusion fractures and from fretting sources. Additional trials were planned which may provide the necessary data for improving the applicability of the AE data. M.S.K.

**A86-41605**

### A FIBER OPTIC DAMAGE MONITOR

C. K. JEN, P. CIELO (National Research Council of Canada, Industrial Materials Research Institute, Boucherville, Canada), G. W. FARNELL, and M. PARKER (McGill University, Montreal, Canada) IN: Review of progress in quantitative nondestructive evaluation. Volume 4B - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 831-838. NSERC-supported research.

A simplified fiber-optic damage monitoring system for on-line assessments of the condition of composite structural materials in F/A-18 fighters is described. Optical fibers are implanted into the composite mesh in a configuration with horizontal and vertical orientations When light is pumped into the fibers, and failure of transmittance in either the x- or y-coordinates indicates the location of a defect at that coordinate, as revealed by the fiber damage. Attaching photodiodes to the optic fibers and connecting the entire system to a video camera and computer permits on-line monitoring of the mesh-holding panels. Sample results are provided from a system with multimode step index fibers, a VAX 11/780 computer and a video camera with a 488 x 380 cell photodiode array. Image subtraction is an effective means for fast determination of the identities of broken fibers by comparisons of images of arrays of original and damaged fibers. M.S.K.

**A86-41631**

### APPLICATION OF MEDICAL COMPUTED TOMOGRAPHY (CT) SCANNERS TO ADVANCED AEROSPACE COMPOSITES

K. D. FRIDDELL, A. R. LOWREY, and B. M. LEMPRIERE (Boeing Aerospace Co., Seattle, WA) IN: Review of progress in quantitative nondestructive evaluation. Volume 4B - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 1239-1245; Discussion, p. 1246.

Computed tomography (CT), developed for medical scans of the human body, is based on the properties of carbon, which is fortuitous for adaptations to NDE of carbon composite materials (CCM). The defects which must be detected in CCM are wrinkling or damage to plies, drying, porosity and microcracks. In attempts to calibrate a CT device for NDE of CCM, specimens were prepared which were composed mainly of compacted powder with water, glycerine and plexiglass additives. Gray scales for density were obtained and compared with wafer-thin samples of the specimens. The technique proved useful not only for measuring density, but also for detecting microcracking. Furthermore, stress tests and subsequent scans of ring-shaped samples demonstrated that the strength of a piece as a whole was dependent on the weakest site, i.e., the lowest density region. M.S.K.

**A86-41673*** Georgia Inst. of Tech., Atlanta.

### CONSTITUTIVE MODELING OF CYCLIC PLASTICITY AND CREEP, USING AN INTERNAL TIME CONCEPT

O. WATANABE and S. N. ATLURI (Georgia Institute of Technology, Atlanta) International Journal of Plasticity (ISSN 0749-6419), vol. 2, no. 2, 1986, p. 107-134. refs
(Contract NAG3-46)

Using the concept of an internal time as related to plastic strains, a differential stress-strain relation for elastoplasticity is rederived, such that (1) the concept of a yield-surface is retained; (2) the definitions of elastic and plastic processes are analogous to those in classical plasticity theory; and (3) its computational implementation, via a 'tangent-stiffness' finite element method and a 'generalized-midpoint-radial-return' stress-integration algorithm, is simple and efficient. Also, using the concept of an internal time, as related to both the inelastic strains as well as the Newtonian time, a constitutive model for creep-plasticity interaction, is discussed. The problem of modeling experimental data for plasticity and creep, by the present analytical relations, as accurately as desired, is discussed. Numerical examples which illustrate the validity of the present relations are presented for the cases of cyclic plasticity and creep. Author

**A86-41699*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

### RESPONSE OF COMPOSITE MATERIAL SHALLOW ARCH TO CONCENTRATED LOAD

E. R. JOHNSON (Virginia Polytechnic Institute and State University, Blacksburg), M. W. HYER (Maryland, University, College Park), and D. M. CARPER (United Technologies Corp., Materials Engineering and Research Dept., Middletown, CT) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, Technical Papers. Part 1, p. 310-321) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 529-536. Previously cited in issue 13, p. 1911, Accession no. A84-31660. refs
(Contract NCC1-15)

**A86-41714#**

### EIGENVALUE REANALYSIS OF LOCALLY MODIFIED STRUCTURES USING A GENERALIZED RAYLEIGH'S METHOD

B. P. WANG (Texas, University, Arlington) and W. D. PILKEY (Virginia, University, Charlottesville) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 983-990. Army-supported research. refs
(AIAA PAPER 84-0972)

Approximate eigenvalue reanalysis methods for locally modified structures are developed based on the generalized Rayleigh's quotients. For simple modifications such as adding springs and masses or changing the truss member's cross-sectional area, closed-form formulas are included. Several applications are presented. Author

**A86-41715#**

**WEIGHT MINIMIZATION OF ORTHOTROPIC FLAT PANELS SUBJECTED TO A FLUTTER SPEED CONSTRAINT**

L. LIBRESCU and L. BEINER (Tel Aviv University, Israel) (ICAS, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1188-1196) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 991-997. Previously cited in issue 22, p. 3256, Accession no. A84-45060. refs

**A86-41883**

**WEIBULL-DISTRIBUTED GROUND CLUTTER IN THE FREQUENCY DOMAIN**

M. SEKINE, T. MUSHA (Tokyo Institute of Technology, Yokohama, Japan), Y. TOMITA, T. HAGISAWA, and E. KIUCHI (NEC Corp., Radio Application Div., Fuchu, Japan) Institute of Electronics and Communication Engineers of Japan, Transactions, Section E (English) (ISSN 0387-236X), vol. E68, June 1985, p. 365-370. refs

Ground clutter from cultivated land was measured using an L-band long range air-route surveillance radar at very low grazing angles, between 0.21 and 0.32 deg. It is shown that the Weibull-distributed ground clutter obeys a Weibull distribution in the frequency domain after processing by the discrete Fourier transform. Thus the new Weibull/CFAR should be considered to suppress such clutter in the frequency domain. Author

**A86-42075**

**A LARGE DISPLACEMENT FORMULATION FOR ANISOTROPIC BEAM ANALYSIS**

M. BORN and T. MERLINI (Milano, Politecnico, Milan, Italy) Meccanica (ISSN 0025-6455), vol. 21, March 1986, p. 30-37. refs

The displacement of a slender prismatic elastic beam, with constant properties along the generatrices and anisotropic and inhomogeneous properties in the cross section, in response to loading at the extreme cross-section surfaces is investigated analytically, expanding on the linear theory of Giavotto et al. (1983). The linear theory is shown to provide the correct elastic section properties and section warping characteristics; the nonlinear formulation gives a generalized geometric section stiffness which takes prestress into account. These results can then be used to construct the elastic and geometric stiffness matrices of a nonlinear beam element suitable for large-displacement analysis of structures such as helicopter rotor blades. T.K.

**A86-42636*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A DETAILED NUMERICAL MODEL OF A SUPERSONIC REACTING MIXING LAYER**

J. P. DRUMMOND, R. C. ROGERS, and M. Y. HUSSAINI (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 18 p. refs

(AIAA PAPER 86-1427)

A current research effort is underway at the NASA Langley Research Center to achieve a detailed understanding of important phenomena present when a supersonic flow undergoes chemical reaction. A computer program has been developed to study the details of such flows. The program has been constructed to consider the multicomponent diffusion and convection of important species, the finite-rate reaction of these species, and the resulting interaction between the fluid mechanics and chemistry. Code results from the analysis of a spatially developing and reacting mixing layer are presented, and conclusions are drawn regarding the structure of the evolving layer and its associated flame. Author

**A86-42658#**

**REDISTRIBUTION OF AN INLET TEMPERATURE DISTORTION IN AN AXIAL FLOW TURBINE STAGE**

T. L. BUTLER, O. P. SHARMA, H. D. JOSLYN, and R. P. DRING (United Technologies Corp., East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs

(AIAA PAPER 86-1468)

The results of an experimental program aimed at determining the extent of the redistribution of an inlet temperature distortion in an axial flow turbine stage are presented. The program was conducted in a large-scale, low speed, single stage turbine where air, seeded with CO2 was introduced at one circumferential location upstream of the inlet guide vane. The migration of the seeded air through the turbine was determined by sensing CO2 concentration inside the stage. A temperature distortion was introduced by heating the seeded air. The CO2 concentration contours measured downstream of the vane showed little change with heating, indicating that the vane flowfield was relatively unaffected by the introduction of the temperature distortion. However, the CO2 contours observed on the rotor airfoil surfaces for the case with inlet heating indicated segregation of hot and cold gas, with the higher temperature gas migrating to the pressure side and the lower temperature gas migrating to the suction side. Significant increases in rotor secondary flow were also observed. Author

**A86-42699#**

**SIMULATION OF ENGINE INSTALLATION FLOWFIELDS USING A THREE-DIMENSIONAL EULER/NAVIER-STOKES ALGORITHM**

J. VADYAK and M. J. SMITH (Lockheed-Georgia Co., Marietta) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 14 p. Research sponsored by the Lockheed Independent Research and Development Program. refs

(AIAA PAPER 86-1537)

A computer analysis has been developed for calculating the steady (or unsteady) three-dimensional flowfield for engine installations. This algorithm, called ENS3D, can compute the engine installation flowfield for subsonic, transonic or supersonic free-stream speeds. The algorithm can solve either the Euler equations for inviscid flow, the thin-shear-layer Navier-Stokes equations for viscous flow, or the full Navier-Stokes equations for viscous flow. The flowfield solution is determined on a body-fitted numerically-generated computational grid. A fully-implicit alternating-direction-implicit method is employed for solution of the finite-difference equations. For viscous computations, a two-layer eddy-viscosity turbulence model is used to achieve mathematical closure. For the present application, the algorithm is applied to compute transport engine installation flowfields at subsonic and transonic free-stream speeds. Author

**A86-42749#**

**INTERACTIONS BETWEEN ACOUSTICS AND VORTEX STRUCTURES IN A CENTRAL DUMP COMBUSTOR**

K. KAILASANATH, J. GARDNER, J. BORIS, and E. ORAN (U.S. Navy, Naval Research Laboratory, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. Navy-sponsored research. refs

(AIAA PAPER 86-1609)

Results are presented of numerical simulations performed to isolate and study the interaction between acoustic waves and large scale vortex structures in a central-dump ramjet combustor. A strong coupling between the acoustic modes of the chamber and large scale vortex structures is observed. The results in the early part of the calculations indicate unforced natural vortex growth near the entrance to the combustor (dump plane) at a frequency close to the acoustic frequency. With time, the acoustic modes shift the frequency of the most amplified mode near the dump plane into resonance with the acoustic mode. The location in space where the modes grow can also be shifted by acoustic forcing. An interesting feature observed in the simulations is a low frequency mode corresponding to the arrival of the merged vortex structures at the choked exit. This mode causes major changes in the merging pattern of the vortices. Author

**A86-42770*#** Pratt and Whitney Aircraft, West Palm Beach, Fla.

**FURTHER DEVELOPMENT OF THE DYNAMIC GAS TEMPERATURE MEASUREMENT SYSTEM**

D. L. ELMORE, W. W. ROBINSON, and W. B. WATKINS (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(Contract NAS3-24228)
(AIAA PAPER 86-1648)

A compensated thermocouple measurement method was experimentally verified. Dynamic signal content from an atmospheric pressure laboratory burner was measured by the dynamic temperature sensor and a relatively delicate fine-wire resistance thermometer. Compensated data from the two dynamic temperature sensor thermoelements were compared with the compensated fine-wire data in the frequency domain. Absolute differences between spectral line amplitudes measured with different sensors are small relative to the mean temperature and verify the compenation method. Increases in precision of the measurement method require optimization of several factors, and directions for further work are identified. Author

**A86-42781#**

**R&M 2000 - A LOOK TO THE FUTURE**

F. S. GOODELL and M. P. SMITH (USAF, Office of the Special Assistant for Reliability and Maintainability, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p. refs
(AIAA PAPER 86-1668)

The U.S. Air Force's Reliability and Maintainability 2000 (R&M 2000) program has as its goals the enhancement of warfighting capability through increased combat support structure survivability measures that reduce mobility requirements for deploying units, decrease manpower requirements for each unit of output, and decrease costs. A key aspect of R&M 2000's implementation strategy is fault isolation down to shop replaceable units system levels in VHSIC technicology. R&M 2000 methods led to the cancellation of a radar warning receiver program that did not meet performance requirements, and resulted in the restructuring of the Low Altitude Navigation and Targeting IR System for Night. O.C.

**A86-43084**

**DAMAGE TOLERANCE ASSESSMENT OF AIRCRAFT ATTACHMENT LUGS**

T. R. BRUSSAT (Lockheed-California Co., Burbank, CA), K. KATHIRESAN (AT&T Bell Laboratories, Marietta, GA), and J. L. RUDD (USAF, Wright Aeronautical Laboratory, Wright-Patterson AFB, OH) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 23, no. 6, 1986, p. 1067-1084. refs

A comprehensive development of damage tolerance design criteria and analysis methods for aircraft attachment lugs is presented. A concise summary is presented of analysis methods and their correlation with test results from 236 fatigue crack growth and 16 residual strength tests of attachment lugs covering a wide variety of design variables. Logic is presented for the selection of an initial flaw size criterion, based upon a survey of cracking data, assessment of NDI capabilities and consideration of manufacturing quality for aircraft attachment lugs. Data are presented showing the damage tolerance of double element (redundant) lugs with a single initial flaw, but other data are discussed showing a high likelihood of multiple fatigue cracking in lugs. Logic is then presented for initial flaw size criteria for multi-load-path attachment lugs which give appropriate credit for redundancy without ignoring the possibility of multiple cracking. Author

**A86-43090**

**THE OASIS STRUCTURAL OPTIMIZATION SYSTEM**

B. J. D. ESPING (Kungl. Tekniska Hogskolan, Stockholm, Sweden) Computers and Structures (ISSN 0045-7949), vol. 23, no. 3, 1986, p. 365-377. refs

OASIS, a modular finite-element structural optimization system compatible with existing FE systems, is characterized and demonstrated. The formulation of the problem and the solution method are explained; design variables for rods, membranes, shells, and sandwiches are given; objective and constraint functions with quasi-numerical derivatives in the first-order approximations are derived; and the 11 modules making up OASIS are briefly described. Sample computations of a civil aircraft wing, a fighter wing, a fighter fin rudder, and a sandwich truck are presented in tables, graphs, and diagrams. T.K.

**A86-43105**

**HOLOGRAPHIC MODE SHAPE INVESTIGATION OF AIRCRAFT ENGINE IMPELLERS**

K. ANTROPIUS (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia) and A. PASLEROVA (Vyzkumny a Zkusebni Letecky Ustau, Prague, Czechoslovakia) IN: Optical methods in dynamics of fluids and solids; Proceedings of the International Symposium, Liblice, Czechoslovakia, September 17-21, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 35-41. refs

The resonant mode shapes of several radial-bladed stationary impellers and of two radial blades removed from the impeller body were investigated by CW-laser holographic interferometry. The greatest attention was paid to the frequency range from 10 to 15 kHz. A retroreflective white paint was used for coating the impeller surface, which helped to enhance the fringes in real-time/time-average visualization, and to shorten the exposure times in hologram recording. Impeller excitation was performed by a set of 10 piezoelectric transducers. In cases with higher-amplitude vibrations a method of additional static exposure was applied. Author

**A86-43109**

**EXPERIENCE WITH LABORATORY LDA BY MEASURING FLOW FIELDS IN ROTATING TURBOMACHINERY**

J. GARDAVSKY, J. PLASEK (Karlova University, Prague, Czechoslovakia), V. DANEK, and J. MASA (CKD-Zavod Kompresory, Prague, Czechoslovakia) IN: Optical methods in dynamics of fluids and solids; Proceedings of the International Symposium, Liblice, Czechoslovakia, September 17-21, 1984 Berlin and New York, Springer-Verlag, 1985, p. 65-74. refs

A laboratory LDA system is operated in the one-color dual-beam mode with confocal annular detection and polarizational separation of the backscattered Doppler signal, allowing for measurements of axial or tangential velocity components up to 600 m/s in absolute coordinates. Doppler signals between the blade passages are gated and evaluated by a counter. The operation of the system is illustrated by measurements of the axial-flow-field velocity component at the impeller of a research turbocharger. Author

**A86-43328#**

**PROSPECTS FOR INTELLIGENT AEROSPACE STRUCTURES**

W. J. ROWE (Lockheed-Georgia Co., Marietta) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 10 p. refs
(AIAA PAPER 86-1139)

An evaluation is made of NDE sensor and instrumentation concepts that have demonstrated promise for the future monitoring of critical structures in flight, in light of past and current efforts to implement such systems and with a view to their operational and economic advantages. Attention is given to the NDE challenges posed by advanced composite laminates, which are affected by both manufacturing and service-incurred defects. Electrical resistance strain gages in various configurations, and optic. fiber-based sensors, are considered as suitable bases for composite materials' NDE systems. O.C.

**A86-43370**

### SOLUTION OF PROBLEMS OF CONJUGATE HEAT TRANSFER DURING FLOW PAST BODIES OF DIFFERENT SHAPE [RESHENIE ZADACH SOPRIAZHENNOGO TEPLOOBMENA PRI OBTEKANII TEL RAZLICHNOI FORMY]

V. I. ZINCHENKO and E. N. PUTIATINA PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Mar.-Apr. 1986, p. 85-93. In Russian. refs

An analysis is made of unsteady heat transfer during the supersonic flow of an ideal gas past axisymmetric bodies of resolution of different shape for Reynolds numbers corresponding to different flow regimes in the boundary layer. Numerical and analytical solutions for heat flux from a nonisothermal surface are compared for laminar flow regimes. It is shown that, in the laminar case, the heat flux to the body has a structure connected with the preliminary development history of the thermal and dynamic boundary layer, and with the value of the local derivative of surface temperature. For certain surface shapes, the use of accepted formulas for the heat transfer coefficient leads to significant errors in the separable formulation of the problem of determining the temperature field in the body. B.J.

**A86-43379**

### CALCULATION OF THE BALANCING EFFICIENCY OF FLEXIBLE ROTORS OF COMPRESSOR UNITS ON LOW-CYCLE BALANCING MACHINES [RASCHET EFFEKTIVNOSTI URAVNOVESHIVANIIA GIBKIKH ROTOROV KOMPRESSORNYKH AGREGATOV NA NIZKOCHASTOTNYKH BALANSIROVOCHNYKH STANKAKH]

A. I. GLEIZER and V. A. BULYCHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 15-19. In Russian.

A method for calculating the efficiency of the low-cycle balancing of flexible rotors on acceleration-type balancing machines is proposed. The method includes a probabilistic estimation of the residual unbalance and a calculation of the limiting level of support vibrations or rotor deflections. The data obtained are compared with norms of residual vibrations permitted under low-cycle balancing. B.J.

**A86-43410**

### THERMAL STABILITY OF GAS TURBINE BLADES WITH PROTECTIVE COATINGS [TERMOSTOIKOST' LOPATOK GAZOVYKH TURBIN S ZASHCHITNYMI POKRYTIIAMI]

A. P. VOLOSHCHENKO, ED., G. N. TRETIACHENKO, ED., L. B. GETSOV, ED., B. M. ZINCHENKO, ED., I. S. MALASHENKO, ED. (Leningradskoe Ob'edinenie Proletarskii Zavod, Leningrad, USSR; AN USSR, Institut Elektrosvarki and Institut Problem Prochnosti, Kiev, Ukrainian SSR) et al. Problemy Prochnosti (ISSN 0556-171X), May 1986, p. 45-50. In Russian.

The thermal stability of turbine blade models with fused slurry and electron-beam coatings has been investigated in gas flow under conditions of thermal cycling, static loading, and sea water exposure. It is shown that blades of various high-temperature alloys (e.g., EP22VD, ZhS6U, EP539VD, and EP539LM) can be effectively protected against sulfide corrosion by using electron-beam coatings of the system Co-Cr-Al-Y. In order to achieve high thermal fatigue strength, tight control of the heating during coating deposition and heat treatment of the blades are essential. V.L.

**A86-43411**

### A METHOD FOR THE ANALYTICAL DETERMINATION OF ACCELERATED TEST SCHEDULES FOR COMPRESSOR BLADES WORKING IN A CORROSIVE MEDIUM [METOD RASCHETNOGO OPREDELENIIA REZHIMOV USKORENNYKH ISPYTANII LOPATOK KOMPRESSOROV, RABOTAIUSHCHIKH V KORROZIONNOI SREDE]

L. B. GETSOV, A. V. PROKPENKO, and V. K. DONDOSHANSKII (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), May 1986, p. 55-60. In Russian. refs

A method is proposed for the analytical determination of accelerated test schedules for gas turbine engines whose effect in terms of the fatigue, corrosion, and erosion of compressor blades is equivalent to that of the entire service life. The method uses an idealized loading scheme and requires the knowledge of experimentally determined fracture toughness characteristics of the blade material. V.L.

**A86-43430*** Murray State Univ., Ky.

### X-RAY FLUORESCENCE ANALYSIS OF WEAR METALS IN USED LUBRICATING OILS

W. E. MADDOX (Murray State University, KY) and W. C. KELLIHER (NASA, Langley Research Center, Hampton, VA) IN: Advances in X-ray analysis. Volume 29. New York, Plenum Publishing Corp., 1986, p. 497-502. refs
(Contract NCCC1-92)

Used oils from several aircraft at NASA's Langley Research Center were analyzed over a three year period using X-ray fluorescence (XRF) and atomic emission spectrometry. The results of both analyses are presented and comparisons are made. Fe and Cu data for oil from four internal combustion engines are provided and XRF and atomic emission spectrometry measurements were found to be in perfect agreement. However, distributions were found in the case of oil from a jet aircraft engine whereby the latter method gave values for total iron concentration in the oil and did not distinguish between suspended particles and oil additives. XRF does not have these particle-size limitations; moreover, it is a faster process. It is concluded that XRF is the preferred method in the construction of a man-portable oil wear analysis instrument. K.K.

**N86-28237#** San Diego State Univ., Calif. Dept. of Aerospace Engineering.

### THE FLOWFIELD OF A SIDE-DUMP COMBUSTOR

N. NOSSEIR and S. BEHAR *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 289-294 Oct. 1985
(Contract N0014-84-K-0373)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Flow visualization is used to study the characteristics of the flowfield of a side-dump combustor. A two-dimensional combustor simulator, with water as the working fluid, is used in this experiment. In this configuration, two jets are introduced into the combustor through rectangular ports in the combustor's sides. The two jets impinge on each other at the plane of symmetry of the combustor. Counter-rotating vortex-pairs are generated near this plane. The axes of the vortices are parallel to the plane of symmetry of the combustor. The strength of the vortices changes periodically as they stretch along the downstream direction. The effects of changing the combustor dimensions on the generation of these vortices are investigated. Author

**N86-28266#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

### APPARATUS FOR THE PREPARATION OF AIR

N. S. NIKOLAYEV, Y. M. ITSKOVICH, A. V. SHCHERBAKOV, T. V. STOYANOVA, and V. V. GOLOVIN 12 Mar. 1986 10 p Transl. into ENGLISH of Russian Patent 302 279, 28 Apr. 1971 p 1-3
(AD-A165603; FTD-ID(RS)T-0134-86) Avail: NTIS HC A02/MF A01 CSCL 13G

The invention deals with equipment for ensuring the maximal reliable operation of devices that pneumatically control air conditioning systems. It can be used, in particular, in an apparatus for preparing air for devices of pneumatic control, for example, air conditioning on aircraft. GRA

**N86-28309#** Rijksluchtvaartdienst, The Hague (Netherlands).

### FUTURE AERONAUTICAL COMMUNICATION SYSTEM (FACS): REPORT

H. J. HOF Jun. 1985 102 p In DUTCH
(ESA-86-96959) Avail: NTIS HC A06/MF A01

The feasibility of a FACS design, particularly with regard to application possibilities of satellites, was investigated. It was assumed that communication between airborne stations and air traffic control centers is exclusively possible via satellites using mainly voice communication (possibly completed by data

communication). It is concluded that integration possibilities of satellites are mainly limited by the airborne antenna chosen. As a solution, phase steered microstrip antenna arrays are presented. However, the use of these antennas is limited to large (long-distance) aircraft. For operational feasibility, it is concluded that communication should take place in the high frequency band.
ESA

**N86-28337#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
**THE IMPACT OF VERY HIGH PERFORMANCE INTEGRATED CIRCUITS ON RADAR, GUIDANCE AND AVIONICS SYSTEMS**
Loughton, England Aug. 1985 396 p In ENGLISH and FRENCH Symposium held in Lisbon, Portugal, 20-25 May 1985
(AGARD-CP-380; ISBN-92-835-0379-1) Avail: NTIS HC A17/MF A01

Advances with silicon integrated circuit technology have demonstrated the feasibility of very large scale integration with gate densities of 10 to the 5th power/sq cm and with functional throughput rates in excess of 10 to the 12th power gate Hz/sq cm. These advances offer the prospect of compact, low power consumption, high throughput processors in a wide variety of roles throughout military electronic systems. This symposium aimed to involve integrated circuit experts who reviewed ththeir current and projected capabilities, circuit and subsystems designers who are exploiting the technology in implementing sophisted processing and data manipulation techniques and who reported on their progress, and system designers who described applications addressed by the advancing technology.

**N86-28341#** TRW Electronics and Defense Sector, Redondo Beach, Calif. Microelectronics Center.
**THE FUTURE OF BIPOLAR TECHNOLOGY FOR AVIONICS**
B. DUNBRIDGE *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 10 p Aug. 1985
Avail: NTIS HC A17/MF A01

In the past 25 years, silicon integrated circuit (IC) device technology has been heavily utilized in military and avionics systems due to primary advantages in availability, versatility, environmental ruggedness/reliability, and speed/frequency performance. Silicon n-channel metal oxide semiconductor (NMOS) technology has also rapidly developed and has been dominant for commercial applications due to its previous advantages of cost and density in modest environments, especially for standard memory and microprocessor functions. Complementary metal oxide semiconductor (CMOS) LSI/VLSI has more recently rapidly emerged as the dominant MOS device technology of the the future. The long held speed performance advantage of silicon bipolar ICS is also being challenged by the superior switching speed of GaAs field-effect transistor (FET) ICs. The question arises as to the future competitiveness and role of silicon bipolar. The question is further examined in this paper, especially for future avionics systems applications having heavy realtime digital signal processing requirements.
B.W.

**N86-28369#** Thomson-CSF, Montrouge (France). Div. Equipements Avioniques.
**THE APPLICATION OF HIGH-PERFORMANCE INTEGRATED CIRCUITS FOR AIRPORT FIRE CONTROL RADARS [INTERET DES CIRCUITS INTEGRES DE HAUTES PERFORMANCES POUR LES RADARS AEROPORTES DE CONDUITS DE TIR]**
J. C. MARCHAIS *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 4 p Aug. 1985 In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

The number of functional modes needed for airport fire control radars, together with the need for high-performance characteristics, indicates that high-performance integrated circuits will have significant applications in such radar. It is shown that multi-function and multi-mode radars which combine air-to-air combat, air-to-ground and air-to-sea modes will comprise the basis for the next generation of fire control radars. Other applications for such radars are shown to include anti-collision, air navigation and air-to-air pursuit modes.
Author

**N86-28371#** Aeritalia S.p.A., Caselle Torinese (Italy). Gruppo Sistemi Avionici ed Equipaggiamenti.
**POSSIBLE IMPACTS OF VHSIC ON MIL-STD-1553B DATA TRANSMISSION MANAGEMENT**
L. BERARDI and M. MERLANO *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 12 p Aug. 1985
Avail: NTIS HC A17/MF A01

High performance integrated circuit technologies allow for dramatic improvement in speed and reduction in size of the integrated circuits. This fact results in the possibility to pack in a denser way the computing and decision making functions of the avionics systems. Nevertheless it is still necessary to connect together the various sytem components, spread through the airframe, by means of an interfunction data transmission system. For these reasons the application of the new technologies to a MIL-STD-1553B data transmission system is considered. In particular the data management task allocated to the Bus Controller is described in four increasing levels of complexity, ranging from the minimum requirement to an 'expert' function including an high degree of configurability. The performance obtainable by implementing the functions in the current or new technologies, and with two different architectural solutions, are measured or estimated. The comparison among the obtained results shows that the new technologies not only improve the performances of the data transmission system, but also allow to include an higher degree of intelligence in the function, extending in this way the application of MIL-STD-1553B to future advanced avionic systems.
Author

**N86-28372#** Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
**THE IMPACT OF VHPIC ON AVIONIC SYSTEM ARCHITECTURE, PACKAGING AND MAINTAINABILITY**
L. T. J. SALMON and D. E. OLDFIELD *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 5 p Aug. 1985
Avail: NTIS HC A17/MF A01

The advent of high performance integrated circuit technology will have a far reaching effect on avionic systems. Currently, the impact is being mainly felt at a high bandwidth, signal processing level where the benefits are self-evident, however, unless the effect of the technology is considered across the whole of the avionic system then there is little doubt that much of the improved mission effectiveness promised by the new, high bandwidth systems will not accrue. A wider, system level approach is therefore needed which not only encompasses the technical aspects of individual sensors but also considers the remainder of the airborne data processing system and more traditional topics such as maintainability, packaging and architecture. This paper highlights some of the areas in which very high performance integrated circuits (VHPIC) could have a major impact on avionics systems and indicates some of the factors that will need to be considered during the design of future systems.
Author

**N86-28373#** Westinghouse Electric Corp., Baltimore, Md. Advanced Technology Div.
**THE IMPACT OF VERY HIGH PERFORMANCE INTEGRATED CIRCUITS ON AVIONICS SYSTEM READINESS**
G. STRULL *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 2 p Aug. 1985
Avail: NTIS HC A17/MF A01

Very high performance integrated circuits (VHPIC) represent more than an integrated circuit technology advance- VHPIC really represents a new systems/technology culture. With a philosophy of top-down design and bottom-up build, a vehicle is provided to avoid rapid obsolescence so prevalent in the fast moving integrated circuit industry. However, to successfully and effectively design advanced systems in this manner, a design methodology is required that adequately addresses the challenge. Since everything from chip definition through application analysis is interactive with everything else, the challenge is to adequately keep track of all the perimeters and their relationship. The methodology by which design and analysis are accomplished is discussed. The starting point is the systems architecture and its application software. From the architecture and application software the partitioning of the system into appropriate modules can be derived. From this an idea of the integrated circuits needed can be determined. The elements of system readiness are described. They are design, implementation, insertion, maintenance, and (Preplanned Product Improvement). Author

**N86-28374#** British Aerospace Aircraft Group, Woodford (England). Aircraft Group.
**THE IMPACT OF ARTIFICIAL INTELLIGENCE ON AIRBORNE MARITIME RECONNAISSANCE**
J. SHEPARD and R. J. SCOTT-WILSON *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 14 p Aug. 1985
Avail: NTIS HC A17/MF A01

Some of the problems arising out of the introduction of VHPIC to the sensor and data processing systems of Maritime Reconnaissance aircraft are susceptible to solution by conventional computing techniques within mission time constraints. Some may be more susceptible to the use of artificial intelligence techniques. This paper identifies those aspects of artificial intelligence relevant to the Airborne Maritime Reconnaissance task and the areas of the current task where artificial intelligence can be usefully applied. It reviews the current state of the art in the relevant aspects of artificial intelligence and indicates how they might be employed in the near, medium and long term. It indicates some future applications and concludes that, artificial intelligence will play an important role in the future Maritime Reconnaissance aircraft. Author

**N86-28375*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FEASIBILITY STUDY OF OPTICAL BOUNDARY LAYER TRANSITION DETECTION METHOD Final Report, 22 Feb. 1983 - 15 Nov. 1985**
M. AZZAZY, D. MODARRESS, and J. D. TROLINGER Jun. 1986 179 p
(Contract NAS1-17293)
(NASA-CR-178109; NAS 1.26:178109; SLD-85-2285-47F) Avail: NTIS HC A09/MF A01 CSCL 20D

A high sensitivity differential interferometer was developed to locate the region where the boundary layer flow undergoes transition from laminar to turbulent. Two laboratory experimental configurations were used to evaluate the performance of the interferometer: open shear layer, and low speed wind tunnel turbulent spot configuration. In each experiment, small temperature fluctuations were introduced as the signal source. Simultaneous cold wire measurements were compared with the interferometer data. The comparison shows that the interferometer is sensitive to very weak phase variations in the order of 0.001 the laser wavelength. An attempt to detect boundary layer transition over a flat plate at NASA-Langley Unitary Supersonic Wind Tunnel using the interferometer system was performed. The phase variations during boundary layer transition in the supersonic wind tunnel were beyond the minimum signal-to-noise level of the instrument. Author

**N86-28377*#** Flow Research, Inc., Kent, Wash.
**FEASIBILITY OF GENERATING AN ARTIFICIAL BURST IN A TURBULENT BOUNDARY LAYER**
M. GAD-EL-HAK Washington NASA Aug. 1986 53 p
(Contract NAS1-17951)
(NASA-CR-4003; NAS 1.26:4003; REPT-332) Avail: NTIS HC A04/MF A01 CSCL 20D

Artificial bursts were generated in laminar and turbulent boundary layers. The burst-like events were produced by withdrawing near-wall fluid from two minute holes separated in the spanwise direction or by pitching a miniature delta wing that was flush-mounted to the wall. Either of these actions generated streamwise vorticity and a low-speed streak that resembled a naturally occurring one. The resulting sequence of events occurred at a given location and at controlled times, allowing detailed examination and comparison with natural, random bursts by means of flow visualization and fast-response probe measurement techniques. Author

**N86-28385*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FEASIBILITY OF A NUCLEAR GAUGE FOR FUEL QUANTITY MEASUREMENT ABOARD AIRCRAFT**
J. J. SIGNH, G. H. MALL (Computer Sciences Corp., Hampton, Va.), D. R. SPRINKLE, and H. CHEGINI (Old Dominion Univ., Norfolk, Va.) Aug. 1986 25 p
(NASA-TM-87706; L-16132; NAS 1.15:87706) Avail: NTIS HC A02/MF A01 CSCL 14B

Capacitance fuel gauges have served as the basis for fuel quantity indicating systems in aircraft for several decades. However, there have been persistent reports by the airlines that these gauges often give faulty indications due to microbial growth and other contaminants in the fuel tanks. This report describes the results of a feasibility study of using gamma ray attenuation as the basis for measuring fuel quantity in the tanks. Studies with a weak Am-241 59.5-keV radiation source indicate that it is possible to continuously monitor the fuel quantity in the tanks to an accuracy of better than 1 percent. These measurements also indicate that there are easily measurable differences in the physical properties and resultant attenuation characteristics of JP-4, JP-5, and Jet A fuels. The experimental results, along with a suggested source-detector geometrical configuration are described. Author

**N86-28389*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**IMPROVEMENT IN THE QUALITY OF FLOW VISUALIZATION IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL**
W. L. SNOW, A. W. BURNER, and W. K. GOAD 1986 24 p
(NASA-TM-87730; L-16108; NAS 1.15:87730) Avail: NTIS HC A02/MF A01 CSCL 14B

Optical diagnostic techniques have not been as successful in the 0.3-Meter Transonic Cryogenic Tunnel as in conventional wind tunnels. This paper describes a simple shadowgraph experiment which allowed evacuation of the optical paths outside the test section. The results show that refractive index variations induced by temperature gradients outside the test section account for most of the image degradation. Earlier reports had erroneously attributed this degradation to inhomogeneities in the test section. Evacuation of the paths leading to and from the test section significantly improves the quality of flow visualization. Author

**N86-28463*#** Aerostructures, Inc., Arlington, Va.
**NASTRAN SUPPLEMENTAL DOCUMENTATION FOR MODAL FORCED VIBRATION ANALYSIS OF AERODYNAMICALLY EXCITED TURBOSYSTEMS**
V. ELCHURI and P. R. PAMIDI (RPK Corp., Columbia, Md.) Jul. 1985 133 p
(Contract NAS3-24387)
(NASA-CR-174967; NAS 1.26:174967) Avail: NTIS HC A07/MF A01 CSCL 20K

This report is a supplemental NASTRAN document for a new capability to determine the vibratory response of turbosystems subjected to aerodynamic excitation. Supplements to NASTRAN Theoretical, User's, Programmer's, and Demonstration Manuals are included. Turbosystems such as advanced turbopropellers with highly swept blades, and axial-flow compressors and turbines can be analyzed using this capability, which has been developed and implemented in the April 1984 release of the general purpose finite element program NASTRAN. The dynamic response problem is addressed in terms of the normal modal coordinates of these tuned rotating cyclic structures. Both rigid and flexible hubs/disks are considered. Coriolis and centripetal accelerations, as well as differential stiffness effects are included. Generally non-uniform steady inflow fields and uniform flow fields arbitrarily inclined at small angles with respect to the axis of rotation of the turbosystem are considered as the sources of aerodynamic excitation. The spatial non-uniformities are considered to be small deviations from a principally uniform inflow. Subsonic and supersonic relative inflows are addressed, with provision for linearly interpolating transonic airloads. Author

**N86-28481#** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.

**STRESS INTENSITY FACTOR IN AN INTEGRAL OR BONDED STIFFENED PANEL USING AN ANALYTICAL METHOD**

J. M. THOMAS and B. LACHAUD 1986 20 p In FRENCH; ENGLISH summary Presented at Colloq. sur les Tendances en Calcul de Struct., Bastia, France, 6-8 Nov. 1985 Submitted for publication

(SNIAS-861-111-104; ESA-86-97141) Avail: NTIS HC A02/MF A01

A mathematical model of a stiffened panel is described. The element is decomposed in a set of subelements for which analytical solutions exist. The results are then superposed respecting the compatibility constraints. The method leads to an economical computation technique to evaluate, for instance, damage tolerance. It is also shown that it could be used for fundamental parametric studies associated with the design of an aircraft. ESA

**N86-29082#** Joint Publications Research Service, Arlington, Va.

**PROPERTIES, APPLICATIONS, FUTURE OF EUROPEAN GYRO SENSORS**

W. HANSLI *In its* Europe Report: Science and Technology (JPRS-EST-86-008) p 29-32 18 Jun. 1986 Transl. into ENGLISH from Wehrtechnik (Bonn, West Germany), Apr. 1986 p 62, 65-66

Avail: NTIS HC A06/MF A01

The mechanical gyroscope was used since the time of World War I as a sensor for measuring angular velocities for the purpose of navigation and flight control. The characteristic configuration was the fixed-in-space mount (cardan mount). With the appearance of the microprocessor, it is now possible to mount gyro devices fixed to the airframe (strapdown mount). Various gyro types are discussed as well as their specific suitability and areas of applications. Future prospects are also examined. B.G.

**N86-29119#** Army Aviation Systems Command, St. Louis, Mo.

**VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS (UH-1 TAIL WHIP ANTENNA EVALUATION)**

J. CARALYUS, J. MILLER, and F. CANSLER Feb. 1986 129 p

(AD-A165897; AVSCOM-TR-85-E-2) Avail: NTIS HC A07/MF A01 CSCL 17B

A full-scale study was conducted by the Naval Air Development Center, Warminster, Penn. (NADC), for the C3 Division of the U.S. Army Avionics Research and Development Activity (AVRADA), Fort Monmouth, N.J., to test and evaluate production prototype antenna systems that essentially met the requirement for SINCGARS operation when installed on an Army UH-1 helicopter. The results of these tests determined a suitable tail whip antenna to be used on the UH-1 to satisfy the SINCGARS requirement between 30 and 88 MHz. This technical report describes the results of tests conducted on antennas manufactured by three major Airborne Antenna manufacturers, each of whom attempted to provide an antenna system that would directly replace the standard Army CU-942B antenna, and satisfy the more stringent requirements of project SINCGARS. The information in this report provides, in part, the technical data for the production data package of an adequate VHF-FM Communications antenna for the UH-1 aircraft. GRA

**N86-29152*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**FLOW DIRECTION MEASUREMENT CRITERIA AND TECHNIQUES PLANNED FOR THE 40- BY 80-/80- X 120-FOOT WIND TUNNEL INTEGRATED SYSTEMS TESTS Final Report, 1 Jan. 1984 - 31 Jul. 1985**

P. T. ZELL, J. HOFFMANN, and D. R. SANDLIN Jul. 1985 71 p

(Contract GNCC2-278)

(NASA-CR-176969; NAS 1.26:176969) Avail: NTIS HC A04/MFA01 CSCL 20D

A study was performed in order to develop the criteria for the selection of flow direction indicators for use in the Integrated Systems Tests (ISTs) of the 40 by 80/80 by 120 Foot Wind Tunnel System. The problems, requirements, and limitations of flow direction measurement in the wind tunnel were investigated. The locations and types of flow direction measurements planned in the facility were discussed. A review of current methods of flow direction measurement was made and the most suitable technique for each location was chosen. A flow direction vane for each location was chosen. A flow direction vane that employs a Hall Effect Transducer was then developed and evaluated for application during the ISTs. Author

**N86-29159*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.

**FLOW PAST A FLAT PLATE WITH A VORTEX/SINK COMBINATION**

N. J. MOURTOS Sep. 1984 51 p Previously announced as N85-25215

(Contract NCC2-149)

(NASA-CR-176908; NAS 1.26:176908; JIAA-TR-58) Avail: NTIS HC A04/MF A01 CSCL 20D

An attempt was made to model the so called leading edge vortex which forms over the leading edge of delta wings at high angles of attack. A simplified model was considered, namely that of a two-dimensional, inviscid, incompressible steady flow around a flat plate at an angle of attack with a stationary vortex detached on top, as well as a sink to simulate the strong spanwise flow. The results appear to agree qualitatively with experiments. A comparison was also made between the lift and the drag of this model and the corresponding results for two classical solutions: (1) that of totally attached flow over the plate with the Kutta condition satisfied at the trailing edge only: and (2) the Helmholtz solution of totally separated flow over the plate. M.G.

**N86-29173#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.

**SHOCK-WAVE BOUNDARY LAYER INTERACTIONS**

J. DELERY (Office National d'Etudes et de Recherches Aeronautiques, Paris, France), J. G. MARVIN (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.), and E. RESHOTKO (Case Western Reserve Univ., Cleveland, Ohio) Feb. 1986 223 p

(AGARD-AG-280; ISBN-92-835-1519-6) Avail: NTIS HC A10/MF A01

Presented is a comprehensive, up-to-date review of the shock-wave boundary-layer interaction problem. A detailed physical description of the phenomena for transonic and supersonic speed regimes is given based on experimental observations, correlations, and theoretical concepts. Approaches for solving the problem are then reviewed in depth. Specifically, these include: global methods developed to predict sudden changes in boundary-layer properties; integral or finite-difference methods developed to predict the continuous evolution of a boundary-layer encountering a pressure field induced by a shock wave; coupling methods to predict entire flow fields; analytical methods such as multi-deck techniques; and finite-difference methods for solving the time-dependent Reynolds-averaged Navier-Stokes equations used to predict the development of entire flow fields. Examples are presented to illustrate the status of the various methods and some discussion is devoted to delineating their advantages and shortcomings.

Reference citations for the wide variety of subject material are provided for readers interested in further study. Author

**N86-29196*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EVALUATION OF A QUARTZ BOURDON PRESSURE GAGE OF WIND TUNNEL MACH NUMBER CONTROL SYSTEM APPLICATION**

W. G. CHAPIN Jul. 1986 19 p

(NASA-TM-88991; NAS 1.15:88991) Avail: NTIS HC A02/MF A01 CSCL 14B

A theoretical and experimental study was undertaken to determine the feasibility of using the National Transonic Facility's high accuracy Mach number measurement system as part of a closed loop Mach number control system. The theoretical and experimental procedures described are applicable to the engineering design of pressure control systems. The results show that the dynamic response characteristics of the NTF Mach number gage (a Ruska DDR-6000 quartz absolute pressure gage) coupled to a typical length of pressure tubing were only marginally acceptable within a limited range of the facility's total pressure envelope and could not be used in the Mach number control system. Author

**N86-29218#** Lockheed-California Co., Burbank.

**DEVELOPMENT OF AN OPERATING PROFILE FOR AIRCRAFT TIRES Final Report**

P. DURUP, M. GAMON, S. BOBO (Transportation Systems Center, Cambridge, Mass.), and S. K. CLARK (Michigan Univ., Ann Arbor.) Jun. 1986 103 p

(Contract DTRS57-80-C-00190)

(FAA/CT-85-32) Avail: NTIS HC A06/MF A01

The procedures of analysis and dynamometer testing that were used to develop data and supporting technology for improving the maintenance and continued airworthiness of civil aircraft tires are described. As related to the inspection, retread and repair of aircraft tires under Advisory Circular AC 145-41, improved criteria which characterize typical tire operating environments and operating scenarios (associated with long range, medium range, and short haul transport airplanes) are defined. Based upon these criteria and scenarios which include tire loading, temperature, and roll distances, means to assess tire fatigue life were developed. Results of this effort may be used for the identification of in-service acceptance criteria and prescribed retread limits. Author

**N86-29236#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

**AIRCRAFT AND BEARING TRIBOLOGICAL SYSTEMS**

Loughton, England Feb. 1986 232 p Meeting held in San Antonio, Tex., 22-26 Apr. 1985

(AGARD-CP-394; ISBN-92-835-1509-9) Avail: NTIS HC A11/MF A01

Advances in aircraft gear and bearing tribology are discussed. Future trends and problems, gear and bearing materials, and lubricants are discussed.

**N86-29238#** Schaefer (Georg) and Co., Schweinfurt (West Germany).

**EFFECTS OF UNFAVORABLE ENVIRONMENTAL CONDITIONS ON THE SERVICE LIFE OF JET ENGINE AND HELICOPTER BEARINGS**

H. K. LOROESCH *In* AGARD Aircraft and Bearing Tribological Systems 9 p Feb. 1986

Avail: NTIS HC A11/MF A01

Aircraft bearings normally operate at high speeds and have to meet demanding reliability requirements. If conventional guidelines for their design are used, the resultant stresses are low. The stresses are particularly low if compared to those customarily applied in testing rolling fatigue. Potential fatigue life, the influence of plastic deformation in the raceways, the influence of surface damage and loading, service life under favorable lubricating conditions, achievable fatigue life at loads above the endurance limit, and the influence of contamination are discussed. Author

**N86-29239#** Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

**AERO-ENGINE GEARS: MANUFACTURING CRACKS AND THEIR EFFECT ON OPERATION**

J. SPECHT *In* AGARD Aircraft and Bearing Tribological Systems 10 p Feb. 1986

Avail: NTIS HC A11/MF A01

The effect of cracks in gear splines is discussed. After black-oxidising of case-hardened gears, stress corrosion cracking may occur. This was determined from damage analysis of cracked gears of flight engines and from sample testing. Besides design measures to reduce operational stresses, corrective action may be in the form of modified manufacturing procedures and improved crack inspection. Author

**N86-29240#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. for Technical Physics.

**TRIBOLOGY IN AIRCRAFT SYSTEMS: BASIC PRINCIPLES AND APPLICATIONS**

E. JANTZEN and V. BUCK *In* AGARD Aircraft and Bearing Tribological Systems 13 p Feb. 1986

Avail: NTIS HC A11/MF A01

The historical origin of the name tribology is outlined. The trends for the next two decades are reviewed: reduction of fuel consumption, improvement of the ratio of specific output to weight, reduction of maintenance, and further improvement of safety. Then the consequences from these trends are outlined with respect to research in tribology. The current status of research is sketched and some unsolved problems are discussed: interaction of material/lubricant in areas with mixed friction (reaction layers); interaction of material/lubricant in the hydrodynamic region; friction and wear of synthetic bearings with and without lubrication; friction, wear and service time if solid lubricants are used; and topographical features of surfaces. Many government sponsored research to gain the wide spread of basic knowledge necessary for new and better solutions. Author

**N86-29241#** Schaefer (Georg) and Co., Schweinfurt (West Germany).

**DESIGN AND CALCULATION OF HIGH SPEED ENGINE BEARINGS**

H. J. KOEBER *In* AGARD Aircraft and Bearing Tribological Systems 12 p Feb. 1986

Avail: NTIS HCA11/MF A01

New aspects in design and calculation of high speed ball and roller bearings are discussed in as much as they affect bearing performance in the speed range of DxN = 3.0 x 1 million min-1 and beyond. For roller bearings the guide flange to roller end configuration as well as roller excursion within the cage pocket are linked to the phenomena of skewing and skidding. The need for under-race-lubrication in small diameter engine bearings is derived from this and a special solution (integral scoop) is shown along with related performance data. The influence of incorporating state of the art rolling elements made of silicon nitride on the design and calculation of high speed ball and roller bearings is shown taking into account hardness, density, Young's modulus and the Poisson ratio. Increase speeds coupled with additional design features being incorporated (such as lubrication holes, grooves, slots) require that inner rings of improved fracture toughness be developed with existing materials of known properties thus supplementing the material development activities already under way. Author

**N86-29243#** KHD Luftfahrttechnik G.m.b.H., Oberursel (West Germany).

**MULTIFUNCTIONAL REQUIREMENTS FOR A GEARBOX SECONDARY POWER SYSTEM IN A MODERN FIGHTER AIRCRAFT AND ITS COMPONENTS AND INTERFACE REQUIREMENTS**

M. PUCHER *In* AGARD Aircraft and Bearing Tribological Systems 14 p Feb. 1986

Avail: NTIS HC A11/MF A01

The basic task of the gearbox in a Secondary Power System (SPS) of an aircraft is to provide and distribute mechanical energy from the Auxiliary Power Unit (APU) or from the Main Engine (ME) to the accessories, e.g., generators, hydraulic pumps and fuel pumps. The complexity as well as the functional facilities increase by incorporating further functional requirements such as main engine start, cross drive operation between redundant systems with the associated control devices, including oil supply to the accessories into the gearbox oil system. The Tornado-SPS is one of the most modern systems flying today. The system shows a high reliability although the aircraft has been in service for only a few years. The experience gained with major components like gearbox housing, gearing, freewheel clutches, dry friction cluthes and components of the oil system is reported. Some aspects from this experience are given for the design of gearboxes for future secondary power systems. Author

**N86-29271*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EXPERIMENTAL CLASSICAL FLUTTER REESULTS OF A COMPOSITE ADVANCED TURBOPROP MODEL**

O. MEHMED and K. R. V. KAZA Jul. 1986 18 p Presented at the Bisplinghoff Memorial Symposium on Recent Trends in Aeroelasticity, Structures and Structural Dynamics, Gainesville, Fla., 6-7 Feb., 1986; sponsored by Fla. Univ.

(NASA-TM-88792; E-3127; NAS 1.15:88792) Avail: NTIS HC A02/MF A01 CSCL 20K

Experimental results are presented that show the effects of blade pitch angle and number of blades on classical flutter of a composite advanced turboprop (propfan) model. An increase in the number of blades on the rotor or the blade pitch angle is destablizing which shows an aerodynamic coupling or cascade effect between blades. The flutter came in suddenly and all blades vibrated at the same frequency but at different amplitudes and with a common predominant phase angle between consecutive blades. This further indicates aerodynamic coupling between blades. The flutter frequency was between the first two blade normal modes, signifying an aerodynamic coupling between the normal modes. Flutter was observed at all blade pitch angles from small to large angles-of-attack of the blades. A strong blade response occurred, for four blades at the two-per-revolution (2P) frequency, when the rotor speed was near the crossing of the flutter mode frequency and the 2P order line. This is because the damping is low near the flutter condition and the interblade phase angle of the flutter mode and the 2P response are the same. Author

**N86-29279#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dir. Scientifique de la Resistance des Structures.

**BOUNDARY LAYER MODEL TO COMPUTE THE EDGE EFFECTS IN STRATIFIED COMPOSITE PLATES Final Report [UN MODELE DE COUCHE LIMITE POUR LE CALCUL DES EFFETS DE BORD DANS LES PLAQUES STRATIFIEES COMPOSITES]**

R. GIRARD Oct. 1985 21 p In FRENCH

(Contract DRET-84-34-001)

(ONERA-RT-7/3542-RY-041-R; ESA-86-97202) Avail: NTIS HC A02/MF A01

The limit conditions are used to modify the classical solution to satisfy the three dimensional conditions, in order to study a complex stress distribution that could result in composite layer delaminating. The general equations of a zero order model are presented. They reveal the interface complex conditions, which are theoretically simple to solve. The practical solutions are not simple, and the particular cases for which a comparison with analytical solutions is possible, are discussed. ESA

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## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-40555**

**THE CALCULATION OF THE ENTROPY DISTRIBUTION ALONG CLOUD TRAVERSES USING AIRCRAFT MEASUREMENTS**

TH. HAUF and J. WEIDNER (DFVLR, Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, West Germany) Meteorologische Rundschau (ISSN 0026-1211), vol. 39, April 1986, p. 33-36. refs

The entropy distribution along horizontal cloud traverses is calculated using aircraft data of high spatial resolution. For the first time, absolute values of entropy inside and outside of clouds are presented. The entropy trace is nearly identical with the humidity trace. Strong fluctuations of entropy are found at the cloud edges. Temperature fluctuations are negatively correlated with the humidity fluctuations and tend to smooth the entropy distribution outside the clouds. The variations in the fields of liquid water content and pressure have negligible effect on the entropy. Results are discussed using the entropy state function. Author

**A86-41035#**

**TAMING THE KILLER WIND SHEAR**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 38-40, 42.

Technical difficulties and bureaucratic hurdles are considered that must be overcome before timely wind shear warnings are routinely available for pilots. The circumstances of the downdraft/microburst wind shear conditions that caused the August 1985 crash of an L-1011 at Dallas/Fort Worth are examined. That crash could have been averted with a timely warning, but the existing system could only provide an alert 1-2 minutes too late. The CLAWS (classify, locate, and avoid wind shear) system - using a single Doppler radar and a beefed up system of anemometers, was a demonstration system developed by the FAA, but it was terminated for budgetary reasons. Lincoln Labs is working on a system with advanced features: ground clutter suppression, automated recognition of microburst and warning issuance. Other organizations working on the problem include NOAA, the Air Force, Sperry, and Raytheon. Real time prediction is still a problem. Improved wind shear safety over the short term depends on Doppler terminal radars and it remains to be seen whether recent crashes will pry from Congress and the Office of Management and Budget the half-billion dollars needed to get them on the air. D.H.

**N86-26588#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.

**PROCESSING AND METEOROLOGICAL EVALUATION OF RESEARCH FLIGHTS WITH DFVLR MOTOR GLIDERS USING THE SOFTWARE PACKAGE RAMF**

J. M. HACKER Jan. 1985 69 p In GERMAN; ENGLISH summary

(DFVLR-FB-85-[illegible]7; ISSN-0171-1342; ESA-86-96877) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 19

The procedures developed for the processing and simple meteorological reduction of data from measuring flights are summarized. Philosophy, construction, and utilization of the software package RAM (routines for the evaluation of meteorological research flights) are described. The routines and the methods for data evaluation are presented and clarified by examples. The accuracy of the derived variables is estimated. ESA

**N86-29486*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
**A SIMPLIFIED MODEL OF THE TURBULENT MICROBURST**
L. ROBERTS and T. WAN Mar. 1985 27 p
(Contract NCC2-270)
(NASA-CR-177108; NAS 1.26:177108; SU-JIAA-TR-59) Avail: NTIS HC A03/MF A01 CSCL 04B

A simple model was developed to describe the low altitude shear associated with a microburst (or small downburst) in the atmosphere. Such microbursts are thought to be the cause of convective radial flows near the ground which represent potentially hazardous conditions to aircraft during approach and landing. Closed form solutions are presented for the equations of mass, momentum, and thermal energy to give the spreading rate of the microburst and the velocity and temperature decay due to turbulence. An analysis of the impact of the microburst and its radial spreading over the ground is given and illustrated examples are provided. The solution for the downward and outward wind velocities are given in terms of simple dimensionless algebraic parameters which can be computed readily in realtime during a piloted simulation of an aircraft flying through a microburst. Author

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## LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

**A86-41782*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**DISPLACEMENT THRESHOLDS IN CENTRAL AND PERIPHERAL VISION DURING TRACKING**
R. F. HAINES (NASA, Ames Research Center, Moffett Field, CA) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, June 1986, p. 548-554. refs

The effects of stimulus duration and angular velocity on a subject's judgment of displacement threshold are examined. Twenty-six male subjects between 17-45 years with uncorrected 20:20 distance acuity and normal color perception and stereopsis studied a series of forced choice, paired comparison trials in which a long, thin, collimated horizontally oriented line moved downward through 12 angles ranging from 0.6-60 arcmin and judged which stimulus moved in each pair. The displacements were produced by 0.25, 0.5, 1, 2, and 4 sec stimulus duration and 2.5, 5, 10, and 15 deg/sec angular rates. Stimulus velocity, stimulus duration, mean threshold displacement, and mean confidence results are analyzed. It is observed that displacement judgment accuracy is increased with increasing stimulus duration. The data are compared with the results of Johnson and Leibowitz (1976) and Johnson and Scobey (1982), and good correlation with the Johnson and Leibowitz data is detected. The data reveal that threshold is based on a constant stimulus velocity over this range of durations and velocities. The data are applicable to the study of the final approach to landing of medium and large commercial jet aircraft. I.F.

**N86-29508*#** Georgia Inst. of Tech., Atlanta. Center for Man-Machine Systems Research.
**PILOT INTERACTION WITH AUTOMATED AIRBORNE DECISION MAKING SYSTEMS Semiannual Progress Report, Mar. - Aug. 1984**
W. B. ROUSE, J. M. HAMMER, N. M. MORRIS, A. E. KNAEUPER, E. N. BROWN, C. M. LEWIS, and W. C. YOON Aug. 1984 45 p
(Contract NAG2-123)
(NASA-CR-177002; NAS 1.26:177002) Avail: NTIS HC A03/MF A01 CSCL 05H

Two project areas were pursued: the intelligent cockpit and human problem solving. The first area involves an investigation of the use of advanced software engineering methods to aid aircraft crews in procedure selection and execution. The second area is focused on human problem solving in dynamic environments, particulary in terms of identification of rule-based models land alternative approaches to training and aiding. Progress in each area is discussed. B.G.

## 15

## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-40760**
**COMPUTER AIDED CONTROL SYSTEM DESIGN USING A MULTIOBJECTIVE OPTIMIZATION APPROACH**
P. J. FLEMING (North Wales, University College, Bangor, Wales) and A. P. PASHKEVICH (Minskii Radiotekhnicheskii Institut, Minsk, Belorussian SSR) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 1 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 174-179. refs

Multiobjective optimization attempts to simultaneously optimize several objectives with respect to the free controller parameters. An evaluation is presently made of multiobjective optimization strategies, with attention to the goal-attainment method; this is applied to three different examples in order to demonstrate the technique: (1) a case highlighting the value of multiobjective optimization in the generation of tradeoff surfaces; (2) a multiregime linear quadratic regulator problem; and (3) the design of a cascade compensator, subject to standard control specifications. Plans for the development of the multiobjective optimization approach as a computer-aided control system design tool are discussed. O.C.

**A86-40762**
**THE DESIGN AND IMPLEMENTATION OF MULTIVARIABLE VARIABLE STRUCTURE CONTROL SYSTEMS**
C. M. DORLING and A. S. I. ZINOBER (Sheffield, University, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 1 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 264-269. refs

The design of the sliding mode in a nominally linear variable structure control system (VSCS) may be completed independently of the form of the actual control functions selected. After defining the nominally linear time-varying and uncertain system that is to be controlled, some of the options available in the design of a stable sliding mode are considered; a canonical form is employed for the design of the hyperplane matrix and the control structure. Attention is given to the eigenstructure assignment method for the design of the sliding mode, and the design of the controller that ensures correct operation in the two stages of the VSCS is outlined. O.C.

**A86-40774**

### AN EXPERT SYSTEM FOR CONTROL SYSTEM DESIGN

T. L. TRANKLE and L. Z. MARKOSIAN (Systems Control Technology, Inc., Palo Alto, CA) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 495-499. Research supported by the McDonnell Aircraft Corp. refs

Work in progress to develop knowledge-based expert systems to supervise adaptive control systems in real time is reported. The overall structure of an expert adaptive controller is outlined, and a detailed description is given of one of its components: the feedback control system designer. This designer uses a planning expert system to supervise the application of computer-aided control system design (CACSD) algorithms. The design of an aircraft feedback control system is mentioned as an example. B.J.

**A86-41934**

### TWO APPROACHES TO HYPERPLANE DESIGN IN MULTIVARIABLE VARIABLE STRUCTURE CONTROL SYSTEMS

C. M. DORLING (Sheffield, University, England) and A. S. I. ZINOBER (Topexpress, Ltd., Cambridge, England) International Journal of Control (ISSN 0020-7179), vol. 44, July 1986, p. 65-82. refs

The design of a stable sliding mode in a variable structure control system is considered in detail. A certain canonical form for the nominal linear system is described, with particular reference to a numerical implementation. Two methods of determining the subspace within which ideal sliding motion occurs are presented, these methods being based on quadratic minimization and eigenstructure assignment. A control structure ensuring the attainment of the sliding mode is summarized, along with a practical method of removing the chatter motion associated with variable structure systems. An example illustrating the methods described is included. Author

**A86-42860**

### ROBUST SIMPLIFIED ADAPTIVE CONTROL FOR A CLASS OF MULTIVARIABLE CONTINUOUS-TIME SYSTEMS

I. BAR-KANA (Rafael Armament Development Authority, Haifa, Israel) and H. KAUFMAN (Rensselaer Polytechnic Institute, Troy, NY) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 141-146. refs

This paper presents a simple and robust adaptive control algorithm for a class of multivariable continuous-time linear systems. Boundedness of all values involved in the adaptation process is guaranteed in the presence of parasitic disturbances and dynamics provided that the controlled plant is stabilizable via unknown static output feedback. The usual need of prior knowledge about the order of the plant and about the pole-excess is also eliminated. Although these techniques can be generalized and their applicability can be extended to systems that need dynamic feedback in order to achieve stability, the present algorithm has its own importance, due to its extreme simplicity of implementation that may facilitate application of adaptive control in realistic complex control systems with unknown parameters. Author

**A86-42871**

### NEW APPLICATIONS OF MU TO REAL-PARAMETER VARIATION PROBLEMS

B. G. MORTON (Honeywell Systems and Research Center, Minneapolis, MN) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 233-238.

The structured singular value (SSV) has been used in recent studies of the robust stability of feedback systems subject to real-parameter variations. In this paper, the results obtained when some new upper-bounds on the SSV for real-parameters were used in two studies of flight control systems are summarized. The perturbation structure for higher rank perturbations is discussed and the issue of lower-bounds for the SSV in the real-parameter problem is considered. A new theoretical result relevant to lower-bounds in a special case is given. Author

**A86-42877**

### A DIFFERENTIAL DYNAMIC PROGRAMMING METHOD WITH AN ABRUPT PENALTY INTEGRAND FOR SOLVING TOLERANCE PROBLEMS

B. JARMARK (SAAB-Scania AB, Linkoping, Sweden) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 287-289.

A nonlinear optimal control problem is considered in respect to a new class of performance index. The problem is to control an output function to be inside a prescribed tolerance zone. When inside the zone, this will result in a favorable cost contribution. When outside there will be no contribution. The numerical optimization algorithm used is a modified differential dynamic programming method. The method is expanded to this class of cost functionals. An example illustrates the difference in using the new cost functional and two other commonly used cost functionals. Author

**A86-42899**

### A COVARIANCE CONTROL THEORY

A. F. HOTZ and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 552-557. refs

A theory is presented for the design of linear feedback controllers in order to arrive at a closed loop system that achieves a specified state covariance. After defining the necessary and sufficient conditions for the existence of constant linear feedback controllers that assign a specified state covariance to the closed loop system, the resulting set of feedback gain matrices are identified. It is shown that when existence is verified, the set of solutions is in general very large. Author

**A86-42912**

### EIGENSTRUCTURE ASSIGNMENT, EIGENSENSITIVITY, AND FLIGHT CONTROL DESIGN

K. M. SOBEL (Lockheed-California Co., Burbank) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 658, 659.

A sensitivity measure which describes changes in the damping of complex conjugate eigenvalues due to changes in the entries of the closed loop system matrix is introduced. An example is presented to illustrate the application of eigenstructure assignment with damping sensitivity reduction to the design of a flight control system. Author

**A86-42957**

### AN ANALYSIS OF A FOUR STATE MODEL FOR PURSUIT-EVASION GAMES

A. J. CALISE and X.-M. YU (Drexel University, Philadelphia, PA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1119-1121. refs

An analysis is given for a four state model useful in medium range air-combat analysis. The problem is formulated as a differential game of degree, with capture time as the performance index. The model is representative of a three-dimensional pursuit-evasion game between two aircraft at medium to large ranges. A complete and exact characterization of the optimal paths and controls is given for arbitrary aerodynamic and propulsion models. Author

**A86-42996**

**INTEGRATED CONTROL - A DECENTRALIZED APPROACH**

A. EMAMI-NAEINI, R. P. ANEX, and S. M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1836-1841. refs

(Contract F33615-82-C-2214)

A decentralized, robust, multivariable controls method is described for the functional integration of subsystems in large-scale systems characterized by dynamic coupling among subsystem elements. In an integrated environment, a decentralized control structure reduces the complexity of the control by distributing the control authority to local controllers. The method relies upon generation of a set of control design specifications for the subsystems. The subsystem designers are provided with design specifications that provide for the integration of control functions. If the subsystem designers can satisfy these specifications, successful integration of the subsystem controls is guaranteed. The specifications are in terms of stability and performance robustness constraints in the frequency domain. The results are applied to an integrated flight-propulsion control example. Author

**A86-43000*** Connecticut Univ., Storrs.

**DUAL CONTROL AND PREVENTION OF THE TURN-OFF PHENOMENON IN A CLASS OF MIMO SYSTEMS**

P. MOOKERJEE, Y. BAR-SHALOM, and J. A. MOLUSIS (Connecticut, University, Storrs) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1888-1893. refs

(Contract NAG2-318; AF-AFOSR-84-0112)

A recently developed methodology of adaptive dual control based upon sensitivity functions is applied here to a multivariable input-output model. The plant has constant but unknown parameters. It represents a simplified linear version of the relationship between the vibration output and the higher harmonic control input for a helicopter. The cautious and the new dual controller are examined. In many instances, the cautious controller is seen to turn off. The new dual controller modifies the cautious control design by numerator and denominator correction terms which depend upon the sensitivity functions of the expected future cost and avoids the turn-off and burst phenomena. Monte Carlo simulations and statistical tests of significance indicate the superiority of the dual controller over the cautious and the heuristic certainity equivalence controllers. Author

**A86-43003**

**TRANSFER OF ALIGNMENT AND CALIBRATION OF MULTIPLE SENSORS IN FLEXIBLE SYSTEMS**

H. C. SALZWEDEL and K. M. KESSLER (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1932-1937. refs

A method for the transfer aligment and calibration of sensors in flexible systems is presented. Flexible systems are represented by high order differential equations and reduced in dimension by model order reduction techniques. Both disturbability of alignment errors by control and disturbance inputs are considered. The reduced order model is decomposed by non-symmetric Riccati decomposition into states that directly and indirectly affect alignment errors. A transfer alignment and calibration filter with control feedthrough is developed and demonstrated for the example of a large flexible aircraft model in turbulence. Author

**A86-43387**

**IDENTIFICATION OF FREQUENCY CHARACTERISTICS DURING BENCH TESTS [IDENTIFIKATSIIA CHASTOTNYKH KHARAKTERISTIK PRI STENDOVYKH ISPYTANIIAKH]**

I. KH. SADYKOV Aviatsionnaia Tekhnika (ISSN 0579-2975) no. 1, 1986, p. 47-52. In Russian.

Consideration is given to the identification of the frequency characteristics during bench tests of aircraft control systems using an analysis of experimental values of the input and output signals. It is shown that, for nonzero values of the initial conditions of the recorded signals, the determination of the frequency characteristics necessarily involves the identification of the parameters of a model of the test object. Algorithms for solving this problem are presented. B.J.

**N86-28359#** Royal Signals and Radar Establishment, Malvern (England).

**MIL-DAP: ITS ARCHITECTURE AND ROLE AS A REAL TIME AIRBORNE DIGITAL SIGNAL PROCESSOR**

P. SIMPSON, J. B. G. ROBERTS, and B. C. MERRIFIELD *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 18 p Aug. 1985

Avail: NTIS HC A17/MF A01

Prototypes of a highly programmable digital processor, Mil-DAP, operating in excess of 300 MOPS and occupying less than a cubic foot will be available in 1985. Its architecture consisting of a large array of processing elements, controlled by a single control unit operating in a Single Instruction Muliple Data (SIMD) mode is described in some detail, including the provision of fast data input-output (up to 40 MBytes/sec), data buffering and programmable data reformation such as corner turning. Two programming languages exist; an assembler language for high efficiency and a higher level parallel form of FORTRAN. The ease of use of both these parallel languages is demonstrated with reference to simple examples. Mil-DAP's performance, size, weight and power consumption suit it well to the wide range of applications encountered in an avionics environment. For example, multimode, radar signal processing incorporating spectral analysis, constant false alarm rate processing and ambiguity resolution; speech recognition as in a voice driven cockpit; electronic support measures where very high speed association and recognition of received pulse information is needed; and reconnaissance image processing, are all potential real time applications. Benchmarks for these are given. Author

**N86-28628*#** National Aeronautics and Space Administration, Washington, D.C.

**NASA SUPERCOMPUTER SYSTEM TO BECOME AVAILABLE NATIONALLY**

D. J. RAHN and P. W. WALLTER (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.) 21 Jul. 1986 2 p

(NASA-NEWS-RELEASE-86-92; P86-10152) Avail: NASA Scientific and Technical Information Facility, P.O. Box 8752, B.W.I. Airport, Md. 21240 CSCL 09B

The most powerful supercomputer facility in the world, the Numerical Aerodynamic Simulation (NAS) system, will go on-line to scientists and engineers throughout the country on July 21, 1986. The NAS supercomputer complex will be linked with 27 remote locations across the country through a combination of high-speed terrestrail and satellite links. The Cray-2 supercomputer was installed as the main computational engine. The NAS CRAY-2 has a 256 million word memory (largest yet available) and can perform 250 million computations a second. The next generation superfast computer currently referred to as the HSP-2 (High Speed Processor-2) is expected to perform a billion computation a second. This will bring the NAS system closer to its near-term goal of having computer with a billion word memory and computational power of 4 billion calculations a second. The NAS system will be relocated to a new computational facility in late 1986 and will be fully operational in March 1987. B.G.

**N86-28673#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**THE USE OF MATHEMATICAL OPTIMIZATION TECHNIQUES BY THE DESIGNER**

R. F. VANDENDAM 25 Jan. 1985 46 p In DUTCH; ENGLISH summary Presented at Congress on Computer Applications in Production and Engineering (CAPE) Nederland '85, Amsterdam, Netherlands, May 1985
(NLR-MP-85005-U; B8578430; ESA-86-98975) Avail: NTIS HC A03/MF A01

Mathematical optimization techniques in the design process and their use by designers are discussed. The principles underlying these techniques and the requirements for a flexible optimization system having a broad applicability are considered. Optimization techniques used in aeronautical engineering are reviewed and illustrated with the examples of the System for the Analysis and Constrainted Minimization of Induced Drag and Computational Aerodynamic Design-by-Optimization System. ESA

**N86-29547*#** Research Triangle Inst., Research Triangle Park, N.C.

**AN EXPERIMENT IN SOFTWARE RELIABILITY Final Report**

J. R. DUNHAM and J. L. PIERCE May 1986 62 p
(Contract NAS1-16489)
(NASA-CR-172553; NAS 1.26:172553; REPT-412U-2094-12; REPT-412U-2094-14) Avail: NTIS HC A04/MF A01 CSCL 09B

The results of a software reliability experiment conducted in a controlled laboratory setting are reported. The experiment was undertaken to gather data on software failures and is one in a series of experiments being pursued by the Fault Tolerant Systems Branch of NASA Langley Research Center to find a means of credibly performing reliability evaluations of flight control software. The experiment tests a small sample of implementations of radar tracking software having ultra-reliability requirements and uses n-version programming for error detection, and repetitive run modeling for failure and fault rate estimation. The experiment results agree with those of Nagel and Skrivan in that the program error rates suggest an approximate log-linear pattern and the individual faults occurred with significantly different error rates. Additional analysis of the experimental data raises new questions concerning the phenomenon of interacting faults. This phenomenon may provide one explanation for software reliability decay. M.G.

**N86-29579*#** Syracuse Univ., N. Y. Dept. of Mechanical and Aerospace Engineering.

**LINEAR AND NONLINEAR DYNAMIC ANALYSIS OF REDUNDANT LOAD PATH BEARINGLESS ROTOR SYSTEMS Status Report**

V. R. MURTHY Dec. 1985 94 p
(Contract NAG2-306)
(NASA-CR-177098; NAS 1.26:177098) Avail: NTIS HC A05/MF A01 CSCL 12A

The bearingless rotorcraft offers reduced weight, less complexity and superior flying qualities. Almost all the current industrial structural dynamic programs of conventional rotors which consist of single load path rotor blades employ the transfer matrix method to determine natural vibration characteristics because this method is ideally suited for one dimensional chain like structures. This method is extended to multiple load path rotor blades without resorting to an equivalent single load path approximation. Unlike the conventional blades, it isk necessary to introduce the axial-degree-of-freedom into the solution process to account for the differential axial displacements in the different load paths. With the present extension, the current rotor dynamic programs can be modified with relative ease to account for the multiple load paths without resorting to the equivalent single load path modeling. The results obtained by the transfer matrix method are validated by comparing with the finite element solutions. A differential stiffness matrix due to blade rotation is derived to facilitate the finite element solutions. Author

**N86-29580*#** Massachusetts Inst. of Tech., Cambridge.

**MULTIVARIABLE CONTROL SYSTEMS WITH SATURATING ACTUATORS ANTIRESET WINDUP STRATEGIES**

P. KAPASOURIS and M. ATHANS May 1985 6 p Sponsored in part by General Electric Co.
(Contract NAG2-297; NGL-22-009-124)
(NASA-CR-177100; NAS 1.26:177100; LIDS-P-1481) Avail: NTIS HC A02/MF A01 CSCL 12A

Preliminary, promising, results for introducing antireset windup (ARW) properties in multivariable feedback control systems with multiple saturating actuator nonlinearities and integrating actions are presented. The ARW method introduces simple nonlinear feedback around the integrators. The multiloop circle criterion is used to derive sufficient conditions for closed-loop stability that employ frequency-domain singular value tests. The improvement in transient response due to the ARW feedback is demonstrated using a 2-input 2-outpurt control system based upon F-404 jet engine dynamics. Author

## 16

## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-41689*#** Missouri Univ., Rolla.

**MODELING WIND TUNNEL EFFECTS ON THE RADIATION CHARACTERISTICS OF ACOUSTIC SOURCES**

W. EVERSMAN (Missouri-Rolla, University, Rolla) and K. J. BAUMEISTER (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 455-463. Previously cited in issue 05, p. 641, Accession no. A85-16104. refs

**A86-43038*** Clemson Univ., S.C.

**COLLOCATION FOR AN INTEGRAL EQUATION ARISING IN DUCT ACOUSTICS**

W. F. MOSS (Clemson University, SC) Journal of Computational Physics (ISSN 0021-9991), vol. 64, June 1986, p. 443-458. refs
(Contract NAS1-17130; NAS1-16394)

A mathematical model is developed to describe the effect of aircraft-engine inlet geometry on the reflected and radiated acoustic field without flow, as studied experimentally using a spinning-mode synthesizer by Silcox (1983). The acoustic pressure in the inlet interior and exterior is modeled by a pure cylindrical azimuthal mode for the Helmholtz equation with hardwall boundary and by the Helmholtz equation and the radiation condition at infinity, respectively. The analytical approach to the solution of the resulting boundary-value problem and the program implementation are explained; numerical results are presented in tables and graphs; and the uniqueness of the problem is demonstrated. T.K.

**N86-28701*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**WIND-TUNNEL ACOUSTIC RESULTS OF TWO ROTOR MODELS WITH SEVERAL TIP DESIGNS**

R. M. MARTIN and A. B. CONNOR Jul. 1986 191 p
(NASA-TM-87698; L-16081; NAS 1.15:87698) Avail: NTIS HC A09/MF A01 CSCL 20F

A three-phase research program has been undertaken to study the acoustic signals due to the aerodynamic interaction of rotorcraft main rotors and tail rotors. During the first phase, two different rotor models with several interchangeable tips were tested in the Langley 4- by 7-Meter Tunnel on the U.S. Army rotor model system. An extensive acoustic data base was acquired, with special emphasis on blade-vortex interaction (BVI) noise. The details of the experimental procedure, acoustic data acquisition, and reduction are documented. The overall sound pressure level

(OASPL) of the high-twist rotor systems is relatively insensitive to flight speed but generally increases with rotor tip-path-plane angle. The OASPL of the high-twist rotors is dominated by acoustic energy in the low-frequency harmonics. The OASPL of the low-twist rotor systems shows more dependence on flight speed than the high-twist rotors, in addition to being quite sensitive to tip-path-plane angle. An integrated band-limited sound pressure level, limited by 500 to 3000 Hz, is a useful metric to quantify the occurrence of BVI noise. The OASPL of the low-twist rotors is strongly influenced by the band-limited sound levels, indicating that the blade-vortex impulsive noise is a dominant noise source for this rotor design. The midfrequency acoustic levels for both rotors show a very strong dependence on rotor tip-path-plane angle. The tip-path-plane angle at which the maximum midfrequency sound level occurs consistently decreases with increasing flight speed. The maximum midfrequency sound level measured at a given location is constant regardless of the flight speed. Author

**N86-28702*#** Pennsylvania State Univ., University Park. Dept. of Physics.
**EXPERIMENTAL STUDY USING NEARFIELD ACOUSTIC HOLOGRAPHY OF SOUND TRANSMISSION THROUGH FUSELAGE SIDEWALL STRUCTURES Final Report**
J. D. MAYNARD 1986 70 p
(Contract NAG1-216)
(NASA-CR-177162; NAS 1.26:177162) Avail: NTIS HC A04/MF A01 CSCL 20A

The reduction of cabin noise in lightweight, propeller-driven aircraft is an especially difficult problem in noise control. Nearfield Acoustic Holography (NAH) was used to determine the mode of vibration and acoustic intensity for panels which differed in: construction (number of stiffening ribs, size of stifening ribs, construction material, and panel surface curvature); boundary support condition (free edge condition or clamped edge condition); and mode of excitation (structural-borne forces or airborne forces). The different samples of aircraft panels are described and the measurement of the natural response frequencies was discussed under various boundary support and excitation conditions. The results of the NAH measurements are presented. B.G.

**N86-29630*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
**MODELING THE EFFECTS OF WIND TUNNEL WALL ABSORPTION ON THE ACOUSTIC RADIATION CHARACTERISTICS OF PROPELLERS**
K. J. BAUMEISTER and W. EVERSMAN (Missouri Univ., Rolla.) Jul. 1986 21 p Presented at the 10th Aeroacustics Conference, Seattle, Wash., 9-11 Jul. 1986; sponsored by AIAA
(NASA-TM-87333; E-2812; NAS 1.15:87333; AIAA-86-1876)
Avail: NTIS HC A02/MF A01 CSCL 20A

Finite element theory is used to calculate the acoustic field of a propeller in a soft walled circular wind tunnel and to compare the radiation patterns to the same propellar in free space. Parametric solutions are present for a 'Gutin' propeller for a variety of flow Mach numbers, admittance values at the wall, microphone position locations, and propeller to duct radius ratios. Wind tunnel boundary layer is not included in this analysis. For wall admittance nearly equal to the characteristic value of free space, the free field and ducted propeller models agree in pressure level and directionality. In addition, the need for experimentally mapping the acoustic field is discussed. Author

**N86-29632*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**INTERACTION OF AIRBORNE AND STRUCTUREBORNE NOISE RADIATED BY PLATES. VOLUME 2: EXPERIMENTAL STUDY**
M. C. MCGARY Jul. 1986 36 p
(NASA-TM-87747; NAS 1.15:87747) Avail: NTIS HC A03/MF A01 CSCL 20A

The interaction of airborne and structureborne noise radiated by aircaraft materials was studied. The results corroborate the findings of an earlier analytical study by showing that the noise radiation of vibrating plates due to combined airborne and structureborne inputs possesses a stong synergistic nature. The large influence of the interaction between the airborne and structureborne inputs was hitherto ignored by researchers of aircraft interior noise problems. Author

**N86-29633*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**INTERACTION OF AIRBORNE AND STRUCTUREBORNE NOISE RADIATED BY PLATES. VOLUME 1: ANALYTICAL STUDY**
M. C. MCGARY Jul. 1986 61 p
(NASA-TM-87746; NAS 1.15:87746) Avail: NTIS HC A04/MF A01 CSCL 20A

The interaction of airborne and structureborne noise radiated by aircraft materials was examined. The theory and results of several computer simulations of the noise radiated by thin, isotropic, rectangular aluminum plates due to fully coherent combined acoustic and vibrational inputs is presented. The most significant finding was the extremely large influence that the relative phase between inputs has on the combined noise radiation of the plates. Phase dependent effects manifest themselves as cross terms in both the dynamic and acoustic portions of the analysis. Computer simulations show that these cross terms can radically alter the combined sound power radiated by plates constructed of aircraft-type materials. The results suggest that airborne-structureborne interactive effects could be responsible for a significant portion of the overall noise radiated by aircraft-type structures in the low frequency regime. This implies that previous analytical and experimental studies may have neglected an important physical phenomenon in the analayses of the interior noise of propeller dirven aircraft. Author

**N86-29636#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
**A STUDY ON THE TRANSMISSION OF SOUND THROUGH FLOW DUCTS OF VARYING CROSS SECTION**
S. W. RIENSTRA 15 Oct. 1983 50 p
(Contract NIVR-311.4-1946)
(NLR-TR-83128-U; B8660348; ESA-86-97503) Avail: NTIS HC A03/MF A01

Sound propagation through axially varying ducts with mean flow is studied. Analytical theories for low and high frequencies are derived. A computer program for Nayfeh's (1980) wave envelope approach was tested to see if bottlenecks could be identified, what parameter range is attainable, and to what extent the classical uniform duct model produces satisfactory results. Although in principle amenable to high frequencies and circumferential periodicities, the method has parts of purely numerical nature, which do not allow a too detailed field; for sound propagating into a contraction (the usual case in a turbo engine intake) the prediction of the uniform duct model seems to be always conservative. A spectacular increase of the reflected wave is found for a combination of high Mach number and thin boundary layer in the contraction. ESA

**N86-29651*#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
**OPTIMAL COOPERATIVE CONTROL SYNTHESIS OF ACTIVE DISPLAYS Final Report**
S. GARG and D. K. SCHMIDT 22 Oct. 1985 160 p
(Contract NAG2-228)
(NASA-177102; NAS 1.177102) Avail: NTIS HC A08/MF A01 CSCL 20F

A technique is developed that is intended to provide a systematic approach to synthesizing display augmentation for optimal manual control in complex, closed-loop tasks. A cooperative control synthesis technique, previously developed to design pilot-optimal control augmentation for the plant, is extended to incorporate the simultaneous design of performance enhancing displays. The technique utilizes an optimal control model of the man in the loop. It is applied to the design of a quickening control law for a display and a simple K/s(2) plant, and then to an F-15 type aircraft in a multi-channel task. Utilizing the closed loop modeling and analysis procedures, the results from the display

design algorithm are evaluated and an analytical validation is performed. Experimental validation is recommended for future efforts.
Author

## 17

## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-42782#**
**THE T800 TURBINE ENGINE SOLICITATION - A NEW THRUST IN STREAMLINING THE ACQUISITION PROCESS**
J. ACURIO and P. E. BROWN (U.S. Army, Aviation Research and Technology Activity, Fort Eustis, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1669)

The request-for-proposal of the T800 engine to be used by the LHX family of military helicopters was structured to reflect interest in a performance-oriented product, stating requirements and defining boundaries without detailing the methods by which results are to be achieved. This resulted in manufacturers' greater flexibility in parametric tradeoff considerations leading to design optimization. Each proposal received gave detailed commitments and guarantees, citing liabilities that would be explicitly for failure to meet contractual requirements.
O.C.

**A86-42783#**
**A SUPPORTABILITY STRATEGY FOR 1995**
J. T. RADEMACHER and G. C. NICHOLSON (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1670)

The use of the Advanced Tactical Fighter in conjunction with the Joint Advanced Fighter Engine to meet such military requirements as supportability, reliability, maintainability and life cycle cost is discussed. Particular attention is given to an approach for handling the evolution in power plant supportability requirements. The GE37 engine which contains fewer engine components, simpler support equipment, a rational engine module design, and integrally bladed disks is presented as a means of demonstrating the success of the logistics support analysis (LSA) process. It is concluded that the proposed weapon system will both lead the way in the LSA process as well as lay the groundwork for the design systems and infrastructure needed to exploit the emerging technologies of computer aided logistics support in the 1990's.
K.K.

**A86-42827#**
**PROPULSION EDUCATION AT THE AIR FORCE INSTITUTE OF TECHNOLOGY**
M. E. FRANKE, W. C. ELROD, and E. J. JUMPER (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p. refs
(AIAA PAPER 86-1754)

Propulsion education and student educational needs at the Air Force Institute of Technology are described. The aeronautics and astronautics programs of which propulsion is a part are reviewed to illustrate typical student programs with a propulsion specialty. Course content and research requirements are described in detail. Computational and laboratory facilities are discussed relative to their importance to propulsion education. Typical propulsion research areas are identified and publications are referenced.
Author

**A86-43333#**
**DEVELOPING A MAINTENANCE CONCEPT FOR FUTURE ELECTRONIC SYSTEMS**
R. O. BLEAU (USAF, Electronic Systems Div., Bedford, MA) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 6 p.
(AIAA PAPER 86-1145)

A team composed of U.S. Air Force acquisitions logisticians and prime contractor logistics and design engineers has used several analytical approaches to identify improvements in maintenance support, design, and logistics contracting strategies. The combination of design and support concepts thus achieved increased system supportability at reduced life cycle cost, and yielded a more combat-capable system. Major focuses of the analytic method used were life cycle costs, capabilities, and flexibility.
O.C.

# SUBJECT INDEX

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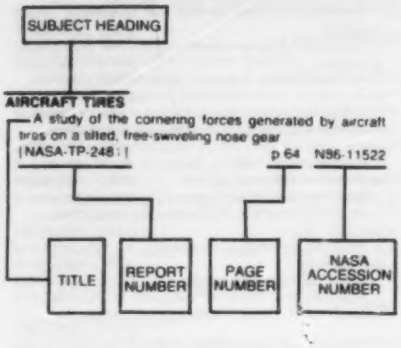

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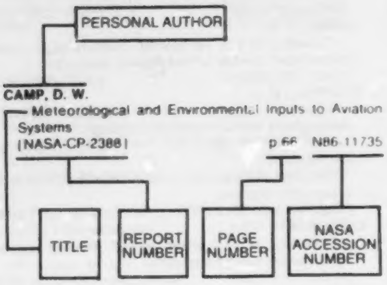
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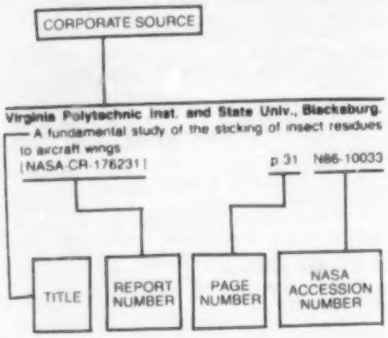
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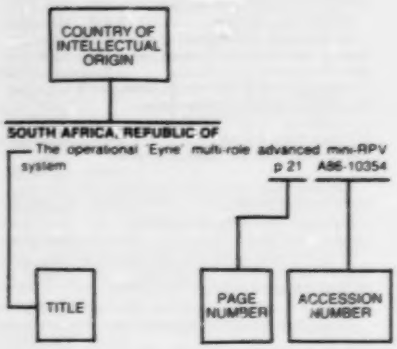
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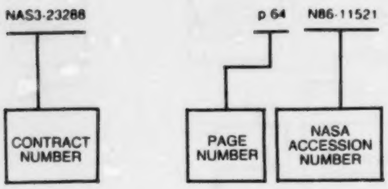

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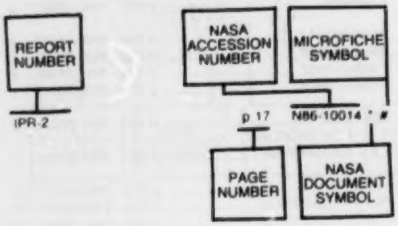

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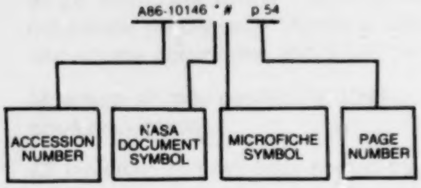

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A Continuing Bibliography with Indexes

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NASA SP-7037(207)

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY
## WITH INDEXES

## (Supplement 207)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in November 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 484 reports, journal articles and other documents originally announced in November 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

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Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

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Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**Category 14 Life Sciences** N.A.

Includes sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

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Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

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Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

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Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

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Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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# TYPICAL REPORT CITATION AND ABSTRACT

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ACCESSION NUMBER → N86-10033*# Virginia Polytechnic Inst. and State Univ., ← CORPORATE SOURCE
Blacksburg. Dept. of Chemistry.
TITLE → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**
AUTHORS → N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs
PUBLICATION DATE
CONTRACT NUMBER → (Contract NAG1-300)
AVAILABILITY SOURCE
REPORT NUMBERS → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF ← PRICE CODE
A01 CSCL 01C
COSATI CODE

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

# TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

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ACCESSION NUMBER → A86-11041*# National Aeronautics and Space Administration.
Langley Research Center, Hampton, Va.
**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS** ← TITLE
AUTHOR → D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) ← AUTHOR'S AFFILIATION
CONFERENCE TITLE → AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs
(AIAA PAPER 85-4076)
CONFERENCE DATE

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 207)*

DECEMBER 1986

## 01

## AERONAUTICS (GENERAL)

**A86-43890#**

**LINE REPLACEABLE MODULES - THE NEXT GENERATION OF AVIONICS**

D. H. WEISS (USAF, Washington, DC) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 187-190.

New trends in avionics, their impact on test equipment, and third generation avionics capabilities are considered. An improved modular automatic test equipment concept is discussed, and an evolution towards third generation Line Replacement Modules instead of Line Replaceable Units and Shop Replaceable Units is indicated. Improved reliability and maintainability is the goal for Air Force second generation avionics, with a more-than 1300 hour mean time between failures required for new systems. It is suggested that new technologies would permit evolution of the USAF test philosophy from an avionics fly-to-failure policy to an avionics integrity program of preemptive removals. Other issues considered are changes due to material and human resource related issues. R.R.

**A86-43906**

**BUILT IN TEST (BIT) UTILIZATION FOR IMPROVED SUPPORTABILITY OF THE F-20 AIRCRAFT**

R. K. WALKER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 446-449.

The use of avionics built-in test (BIT) as a fundamental part of off-aircraft support is demonstrated using F-20 avionics systems. The F-20 avionics systems briefly described here include the head-up display, the digital display indicator, the display processor, the data entry panel, the armament control panel, the mission computer, the multimode radar, the inertial navigation set, the pylon interface unit, the AIM-9 missile interface unit, and the communications, navigation identification interface unit. The equipment manufacturers are named and the projected mean time between failures is given. The application of BIT to these systems is described, and the improved reliability of this new generation of avionics is compared with that of the complex and expensive Avionics Intermediate Shops of the present. C.D.

**A86-44006#**

**DOUBLING THE AIR FORCE THROUGH GREATER RELIABILITY**

R. T. RODENROTH (USAF, Advanced Tactical Fighter Office, Wright-Patterson AFB, OH) Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 44-46.

The U.S. Air Force, in studies conducted in anticipation of Advanced Tactical Fighter (ATF) design and performance requirements, has determined that greater attention to reliability and maintenance considerations should result not merely in cost reductions but in force-multiplying effects. At any given time, 90-92 percent of the ATF force will be available for use; half the aircraft grounded for maintenance should be ready to fly again in two hours, 75 percent in four hours, and fully 85 percent in eight hours. The ATF should also require only 8.7 maintainers per aircraft, which is less than half as many as those servicing current fighter aircraft. O.C.

**A86-44284**

**METHODS OF THE ASSEMBLY OF AIRCRAFT INSTRUMENTATION AND SYSTEMS [TEKHNOLOGIIA MONTAZHA PRIBORNOGO OBORUDOVANIIA LETATEL'NYKH APPARATOV]**

V. A. NEGREBA and L. V. MARKIN Moscow, Izdatel'stvo Mashinostroenie, 1985, 312 p. In Russian. refs

The book is concerned with methods, tools, and special techniques used in the assembly of on-board instrumentation and various aircraft systems. In particular, attention is given to general metal working and assembly techniques, assembly of electrical equipment and wiring, electric measurements and electric testing equipment, and assembly of navigation and control systems. The discussion also covers the assembly of high-altitude and oxygen systems, television and photographic equipment, and safety engineering. V.L.

**A86-44291**

**FUNDAMENTALS OF AVIATION TECHNOLOGY AND AIRPORT EQUIPMENT [OSNOVY AVIATSIONNOI TEKHNIKI I OBORUDOVANIE AEROPORTOV]**

V. I. BLOKHIN, ED. Moscow, Izdatel'stvo Transport, 1985, 256 p. In Russian. No individual items are abstracted in this volume.

The fundamental of aerodynamics, flight dynamics, and general aircraft design are presented, as are the basic principles of aircraft service and maintenance and characteristics of the main types of airfield equipment. In particular, attention is given to ground power supply sources, compressed air supply, towing and cleaning machines, and equipment for the storage and handling of fuels and lubricants. The discussion also covers navigation and ranging equipment, light signals, and the electric power supply system of airfields. V.L.

**A86-44422#**

**GENERIC INTEGRATED MAINTENANCE DIAGNOSTICS**

H. M. SEAMAN (USAF, Directorate of Support Systems Engineering, Wright-Patterson AFB, OH) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, June 1986, p. 9-12.

An Air Force program designated GIMADS (Generic Integrated Maintenance Diagnostics) has been initiated to pursue a systems approach to weapon system maintenance using both prognostics and diagnostics. The program is an outgrowth of a study by the Air Force Operational Test and Evaluation Command of field maintenance effectiveness for the E-3A, EF-111 and F-16 aircraft. The 1984 directive initiating GIMADS stressed the requirement for 100 percent fault detection and isolation of weapon system faults by an optimized combination of testing techniques. Over a five-year period, the program will utilize a combination of ASD in-house engineering and contracted engineering support to gather data, perform studies and analyses, prepare technical and management

documentation, and develop hardware and software tools needed to implement an integrated diagnostics approach to maintenance for both electronic and nonelectronic systems. Technical integration will be accomplished by ASD engineering, and will consider and utilize on-going integrated diagnostics efforts in industry and government.
D.H.

**A86-44442**
**LAUNCHING THE AEROSPACE PLANE**
T. A. HEPPENHEIMER High Technology (ISSN 0277-2981), vol. 6, July 1986, p. 46-51.

A discussion is presented concerning the performance requirements, the possible configurational, structural, and propulsion system features, and the R&D program management aspects, of the proposed 'aerospace plane'. Attention is given to the tradeoffs that must be considered in the use of airbreathing rather than rocket engines, as well as to the advanced refractory materials and fabrication techniques called for by high friction temperature, hypersonic flight, and the comparative advantages of various proposed fuels and engine multiple cycle schemes. NASA, DARPA, and British Aerospace are noted to be the most prominent research institutions in the development of aerospace plane designs.
O.C.

**A86-44919**
**WORLD AEROSPACE PROFILE 1986**
London, Sterling Publications, Ltd., 1986, 352 p. No individual items are abstracted in this volume.

A comprehensive evaluation is made of state-of-the-art achievement and development trends for numerous fields in aerospace technology throughout the industrial world, with attention to airframe, engine and avionics manufacturers in the U.S., U.K., France, West Germany, and Japan. Both civilian and military programs are discussed in articles covering composite airframes for materials, anticorrosion design practices, tilt-rotor aircraft design, next-generation SSTs, supersonic STOL and V/STOL development trends, Unducted Fan engine design evolution, propeller design trends, and novel aviation fueling methods. Also discussed are avionics for all glass cockpits, HUDs, future ATC developments, RPVs, flight simulators, advanced components, safety systems, commercial aircraft interior design, airport and airline planning, and financial management.
O.C.

**A86-44935**
**THE SELECTION AND ACQUISITION OF COMMERCIAL AIRCRAFT FLEETS**
W. PETERS (South African Airways, Johannesburg, Republic of South Africa) Aeronautica Meridiana (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 43-50.

Fleet planning, aircraft selection and aircraft acquisition processes must be constantly undertaken by airlines irrespective of their size, and will have as their primary concern the matching of aircraft performance characteristics with market route networks, on the one hand, and on the other the large amounts and high cost of capital for fleet refurbishment. Other considerations encompass market analyses, the purchase of new or used aircraft, aircraft performance suitability for certain route sectors, and the guarantee of engine and airframe manufacturers' performance specifications.
O.C.

**A86-45063**
**NEW TECHNOLOGIES OFFER QUANTUM LEAP IN FUTURE FIGHTER CAPABILITIES**
R. R. ROPELEWSKI Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 48, 49, 51, 52.

A new generation of airframe, engine, materials, and avionics technologies which will provide substantial performance, reliability, and survivability gains in future fighter aircraft is discussed. The expected advances in structures and materials, propulsion, avionics, and stealth are examined, including the contributions of the USAF advanced tactical fighter (ATF) the USN advanced tactical aircraft (ATA), and the multinational European fighter aircraft (EFA) programs. The characteristics of the super cockpits now under development, the first of which will enter full-scale development around 1990, are briefly addressed.
C.D.

**A86-45065**
**NASA'S LANGLEY CENTER MAKING GAINS IN ADVANCED TECHNOLOGY PROJECTS**
D. M. NORTH Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 85, 87, 89.

Research projects at NASA's Langley Research Center aimed at achieving increased maneuverability in high angle of attack flight using multiaxis thrust vectoring in future fighter aircraft are discussed. Development programs to establish generic technology for aircraft beyond the USAF advanced tactical fighter and the USN advanced tactical aircraft are considered. The F/A-18 prototype acquired from the Navy will be used as a test bed. Wind tunnel testing of pylon, tangent, and semisubmerged pallet weapon mounting concepts on a generic aircraft wing is described, as is a leading edge flap vortex research program for fighter and attack aircraft. Future flight control systems for new technology aircraft which will accommodate the expanded flight envelopes permitted by thrust vectoring are discussed.
C.D.

**A86-45704#**
**LHX TARGETS DOLLARS AS WELL AS BOGEYS**
G. K. ANDRESON (U.S. Army, Aviation Systems Command, Saint Louis, MO) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 24-27.

The Army is reported to be working on the initial stages to develop a Light Helicopter family (LHX) to supplant its aging fleet of light rotorcraft. Affordability will be a key concern. Mission gross weight for the single-pilot scout and attack version called SCAT must be only 7500-8500 lb. Its flyaway cost must not exceed $6 million in 1984 dollars, and that of the utility version must be held to $4 million. Instead of the usual array of instruments and switches requiring pilot attention and physical actions, the SCAT cockpit will be simplified, integrated, and largely automated. SCAT will include a Mission Equipment Package (a sort of central nervous system) with sensors, processors, displays, controls and flight management interconnections. The helmet-mounted display approach is being considered. Considerable work will be required to develop workable software and assure that sufficient mission reliability is achieved. Prospective contractors include Boeing-Vertol/Sikorski, Bell, and Hughes; Hughes has been acquired by McDonnell Douglas, which has teamed with Bell. All have developed technology test beds. The request-for-proposals point is expected to be reached in March 1987.
D.H.

**A86-46199#**
**CFRP-WING FOR THE ALPHA JET**
D. ROSER Dornier Post (English Edition) (ISSN 0012-5563), no. 2, 1986, p. 21-24.

Carbon-fiber reinforced plastic (CFRP) wings were developed for the Alpha jet to control production costs while providing structural strength as high as that available from metals. The wings were required to satisfy the mission, operational range and flight envelope of the aircraft. The CFRP mixture selected was chosen on the basis of the environmental and external forces it would encounter, weight and optimal design constraints, the ability to handle complex loads, and the readiness of suitable quality control technologies. The wings have aluminum ribs and attachment fittings which were already qualified for the aircraft. Sample coupons of the CFRP material met the mechanical properties test criteria and a multi-rib configuration was selected as an additional weight saving measure. The manufacturing techniques for producing the complex composite components are outlined.
M.S.K.

**N86-29762*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**MOTION AND INTERACTION OF DECAYING TRAILING VORTICES IN SPANWISE SHEAR WIND**
C. H. LIU and T. LU (New York Univ., New York.) Sep. 1986 26 p
(NASA-TP-2599; L-16040; NAS 1.60:2599) Avail: NTIS HC A03/MF A01 CSCL 01B

A simulation is presented of the drift of trailing vortices in a cross-wind near the ground by an unsteady, two-dimensional, rotational flow field with a concentration of large vorticity in vortical spots (having a finite but small effective size and finite total strength). The problem is analyzed by a combination of the method of matched asymptotic analyses for the decay of the vortical spots and the Euler solution for the unsteady rotational flow. Using the method of averaging, a special numerical method is developed in which the grid size and time step depend only on the length and velocity scales of the background flow and are independent of the effective core size of a vortical spot. The core size can be much smaller than the grid size, whereas the peak velocity in the core is inversely proportional to the spot size. Numerical results are presented to demonstrate the strong interaction between the trajectories of the vortical spots and the change of the vorticity distribution in the background flow field. Author

**N86-29763#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**INTRODUCTION TO THE RECENT DEVELOPMENTS OF CHINA'S CIVIL AVIATION**
11 Mar. 1986 10 p Transl. into ENGLISH from Hangkong Zhishi (China), no. 1, 1985 p 11-12
(AD-A166194; FTD-ID(RS)T-1165-85) Avail: NTIS HC A02/MF A01 CSCL 01B

The Civil Aviation Administration of China, abbreviated CAAC, is in charge of the whole China civil aviation system. It is different from ordinary airline companies but similar to the Traffic Administration of the Japan Transportation Ministry. Its responsibility includes making policy and regulations for civil aviation, aviation traffic, operation and maintenance of civil airlines, selling of airline tickets and other commodities, management of airports, passenger lounges and anything related to civil aviation. GRA

**N86-29764#** Air Command and Staff Coll., Maxwell AFB, Ala.
**THE SEARCH FOR AN ADVANCED FIGHTER: A HISTORY FROM THE XF-108 TO THE ADVANCED TACTICAL FIGHTER**
R. P. LYONS, JR. Apr. 1986 101 p
(AD-A166724; ACSC-86-1575) Avail: NTIS HC A06/MF A01 CSCL 05A

This report traces the Air Force's progress in developing advanced fighters from the XF-108 and the YF-12A for long-range supersonic interception; through the F-111 with its goal of multi-mission commonality through the F-15 air superiority fighter; then to the Lightweight Fighter Prototypes (YF-16 and YF-17) and the Air Combat Fighter competition won by the F-16. The report also covers the technology and fighter enhancement programs (such as AFTI, HiMAT, X-29A, and MSIP) which build the base for the Advanced Tactical Fighter now in Concept Development. GRA

**N86-30627#** Deutsche Gesellschaft fuer Luft- und Raumfahrt, Bonn (West Germany).
**THE SECOND INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS**
1985 713 p Symposium held in Aachen, West Germany, 1-3 Apr. 1985; sponsored in cooperation with DFVLR, NLR and ONERA
(DGLR-85-02; ISBN-3-922010-28-8; ESA-86-97411) Avail: NTIS HC A99/MF E03

Unsteady aerodynamics and aeroelastic characteristics; active control technology; structural modeling and optimization; structural system identification; and structural dynamics design verification of space structures were discussed. ESA

**N86-30661#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Structural Mechanics.
**EFFECTS OF ANISOTROPIC DESIGN ON THE STATIC AEROELASTICITY OF A SWEPT WING**
M. PIENING *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 451-456 1985
Avail: NTIS HC A99/MF E03

A simple structural idealization is adopted to model an arbitrary swept anisotropic wing of moderate to high aspect ratio. The related differential equations are solved for the deformations and internal forces by multiple shooting. The divergence speed is calculated by searching the lowest eingenvalue of the structural matrix formed from the transfer matrices of the wing sections and the according boundary conditions. Parametric evaluations are performed. ESA

**N86-30690#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**INTERNATIONAL AVIATION (SELECTED ARTICLES)**
T. SHEY-SHI, K. M. HSU, I. T. KUO, and C. HUANG 14 Mar. 1986 35 p Transl. into ENGLISH from Guoji Hangkong (China), no. 2(264), Feb. 1985 p 24-26; 27-29; 45-46
(AD-A166748; FTD-ID(RS)T-0843-85) Avail: NTIS HC A03/MF A01 CSCL 01C

Following are the partial contents of a report on international aviation: A few points on longitudinal jet ejection techniques; Foreign technology studies on external store separation; Stealth aircraft technology Current development and future prospects. GRA

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A86-43485#**
**A SECOND-ORDER THEORY FOR THREE-DIMENSIONAL UNSTEADY FLOWS AND ITS APPLICATION TO THIN WINGS WITH ANGLE OF ATTACK AT SUPERSONIC AND HYPERSONIC SPEEDS**
L. HE, Y. HAN, and F. QIAN (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 585-589. In Chinese, with abstract in English.

**A86-43501#**
**SOME PROBLEMS IN THE FINITE-DIFFERENCE COMPUTATION OF THREE-DIMENSIONAL TRANSONIC FLOWS**
T. CHEN (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 104-107. In Chinese, with abstract in English.

The mixed finite-difference relaxation iteration method is applied to the calculation of the wing-body combination with rectangular wings. It is based on the three-dimensional transonic small-disturbance potential equation in the cylinder coordinates. The effect of different computation regions and relaxation parameters (on subsonic points) on the ranges of the computed Mach numbers, angles of attack and calculated results is also studied. It is shown that extending the computation limits brings an increase in the convergence rates of the small-disturbance equation. The convergence rate and computation accuracy are enhanced if the subsonic relaxation parameter is supposed to be 1.9. It is also demonstrated that the calculated results differ when the finite or infinite regions are taken as the computation region of the r-direction. Particularly the distribution of the pressure

coefficients near the wingtip varies as the incident Mach number becomes larger.
Author

**A86-43512#**

### MEASUREMENTS OF FLUCTUATIONS OF SURFACE HEAT TRANSFER RATE IN THE INTERACTING REGION OF OBLIQUE SHOCK WAVE AND TURBULENT BOUNDARY LAYER

M. HAYASHI, S. ASO, and A. TAN (Kyushu University, Fukuoka, Japan) Kyushu University, Technology Reports (ISSN 0023-2718), vol. 58, Dec. 1985, p. 1001-1006. In Japanese, with abstract in English. refs

Fluctuations of surface heat-transfer rate have been measured in the regions of interaction between an oblique shock wave and a turbulent boundary layer. A new type of heat-transfer-rate gage with high spatial resolution and fast response is used. Experiments were made at a nominal Mach number of 4, wall temperature condition Tw/To of 0.56, and Reynolds number of 1.26 x 10 to the 7th based on the distance from the flat-plate leading edge. Measurements were made under separated and unseparated boundary-layer conditions, depending on different incident shock-wave strength. When the boundary layer is separated, significant fluctuations of the heat-transfer rate are observed throughout the interaction region, particularly near the separation point, at the end of the wall pressure plateau, and near the reattachment point. Near the separation point, intermittency is observed in the heat-transfer rate. It changes remarkably with a small length scale. When the boundary layer is unseparated, fluctuations of the heat-transfer rate get strong near the impinging point of the incident shock, but no intermittency is observed. The fluctuations are nearly Gaussian throughout the interaction.
Author

**A86-43514#**

### FLUCTUATIONS OF WALL PRESSURE IN THE INTERACTING REGION OF OBLIQUE SHOCK WAVE AND TURBULENT BOUNDARY LAYER

M. HAYASHI, S. ASO, and A. TAN (Kyushu University, Fukuoka, Japan) Kyushu University, Technology Reports (ISSN 0023-2718), vol. 59, Jan. 1986, p. 75-82. In Japanese, with abstract in English. refs

Fluctuations of wall pressure have been measured in the region of interaction between an oblique shock wave and a turbulent boundary layer. Experiments were made at a nominal Mach number of 4, wall temperature condition Tw/T0 of 0.56, and Reynolds number of 1.26 x 10 to the 7th based on the distance from the flat plate leading edge. When boundary layer is separated, significant fluctuations of wall pressure are observed throughout the interaction region. Near the separation point, intermittency is observed in wall pressure signals. The fluctuations change remarkably with a small length scale. The distribution of intensity of wall pressure fluctuations shows the same tendency as that of the surface heat transfer rate fluctuations. Both of them have a sharp peak near separation point. When the boundary layer is unseparated, the fluctuations of wall pressure show a peak near the impinging point of the incident shock wave, but no intermittency is observed.
Author

**A86-43533#**

### FLOWS PAST A ROTATING CIRCULAR CYLINDER AT HIGH REYNOLDS NUMBER

T. KIMURA and M. TSUTAHARA (Kobe University, Japan) Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, April 1986, p. 188-194. In Japanese, with abstract in English. refs

Flows past a rotating circular cylinder at high Reynolds number are investigated by a discrete vortex method. The nascent vortices are introduced to the flowfield at each time step from several points uniformly distributed around and near the surface of the circular cylinder. Calculations are performed for omega = 0.5, and 1.0, where omega is the angular velocity of rotation, and equals the specific speed, i.e., in this case, the ratio of the peripheral velocity to the uniform flow. The results agree qualitatively with experimental results. The reverse Magnus effect, however, due to the transitions of the boundary layers on the upper side and the lower side of the circular cylinder, did not appear, and the simulation for this by the present method seems to be difficult.
Author

**A86-43938#**

### THE EFFECT OF RAIN AND CONTAMINATION OF THE FRONT SURFACE ON THE IN-FLIGHT BEHAVIOR OF AIRCRAFT DURING ROLL. II [WPLYW DESZCZU I ZANIECZYSZCZEN POWIERZCHNI NOSNEJ NA ZACHOWANIE W LOCIE SAMOLOTOW O UKLADZIE KACZKI. II]

Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Jan. 1986, p. 16-18. In Polish.

**A86-44238**

### APPLICATION OF UNSTEADY AERODYNAMICS TO LARGE-EDDY BREAKUP DEVICES IN A TURBULENT FLOW

P. BALAKUMAR and S. E. WIDNALL (MIT, Cambridge, MA) Physics of Fluids (ISSN 0031-9171), vol. 29, June 1986, p. 1779-1787. refs
(Contract F49620-83-C-0019)

The modifications to the vertical velocity of a turbulent flow by the large-eddy breakup devices (LEBU) were analyzed using linear three-dimensional unsteady aerodynamics. A Fourier component of the input turbulence convected over these devices was considered and the modified vertical velocity in the far downstream wake was solved. It is shown that the amplitude of the vertical velocity behind the device is reduced, the effect increasing with increasing stream and spanwise wavenumber. Two plates placed far apart in series produce a reduction that is the square of that for a single plate. The presence of the ground plane decreases the effectiveness of the LEBU in reducing the amplitude of the vertical velocity in the far wake.
Author

**A86-44802**

### THE REVERSE-FLOW THEOREM FOR TRANSONIC FLOW

G. SCHNERR and J. ZIEREP (Karlsruhe, Universitaet, West Germany) IN: Flow of real fluids . Berlin and New York, Springer-Verlag, 1985, p. 17-27. refs

A generalized form of the reverse flow theorem (RFT) is developed for airfoils with contours symmetrical to the maximum thickness in transonic flows and considered for its range of applicability. The prime concern with the RFT is that the pressure drag of the body remain constant even if the flow is reversed, i.e., the drag freezing criterion. The use of the RFT is validated for the hodograph method for double-wedge profiles. A parabolic method is formulated for applying the RFT to a Guderley cusped nose profile. The calculations are extended to supersonic flows. Comparisons with experimental data and Schlieren photographs from a Guderley profile in a shocked wind tunnel illustrate the accuracy of the RFT calculations when the freezing criterion is satisfied.
M.S.K.

**A86-44803**

### ON AERODYNAMIC SOUND GENERATION BY AIRFOIL-VORTEX INTERACTION

F. OBEMEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) IN: Flow of real fluids . Berlin and New York, Springer-Verlag, 1985, p. 41-50. refs

An analytical examination is carried out of aerodynamic sound generation by blade vortex interaction, such as happens with helicopter blades, to demonstrate the difficulties in accurately modeling the sound field. The discussion covers the Mach numbers up to transonic flows, concentrating on a single line vortex sweeping past the leading edge of a semi-infinite solid plate in a flow parallel to the plate. Sound field properties dominate in the outer region, away from the leading edge, while hydrodynamical incompressibility effects are most important in the inner region near the leading edge. Models are developed for both fields and approximate expressions are defined for acoustic effects in the far field. A Hamiltonian formalism is used for the vortex path. Compressibility effects in the inner region are considered to extend the model to transonic flows. Further investigations required to characterize the leading edge flow and to equate unsteady vortex motion with sound wave propagation are indicated. M.S.K.

**A86-44810**
**ON SLENDER VORTICES**
E. KRAUSE (Aachen, Rheinisch-Westfaelische Techische Hochschule, West Germany) IN: Flow of real fluids . Berlin and New York, Springer-Verlag, 1985, p. 211-218.

A numerical model is developed for the breakdown of slender vortices. The model considers the conditions which will permit the vortices to remain slender, noting the necessity of maintaining small axial pressure gradients and limitations on the magnitude of circumferential velocity variations. Local accelerations of the axial velocity components are also permitted. Inviscid theory shows that breakdown is controlled by an axial pressure gradient imposed by the external flow and on a swirl component which causes the flow to become unsteady. Viscosity, although significant in core dissipation, does not have a significant impact on breakdown. M.S.K.

**A86-44855*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FAR-FIELD BOUNDARY CONDITIONS FOR TRANSONIC LIFTING SOLUTIONS TO THE EULER EQUATIONS**
J. L. THOMAS and M. D. SALAS (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1074-1080. refs

Far-field boundary conditions for the Euler equations are formulated and applied to transonic lifting flow over an airfoil in an unbounded domain. An expansion of the linearized small-disturbance equation in the far field is developed and the leading-order term, corresponding to a point vortex representation for the airfoil, is retained. A comprehensive evaluation across the Mach number range of the procedure's effectiveness in eliminating dependence of the numerical results on the boundary extent is presented. Extension of the method to three dimensions is also outlined. Author

**A86-44874#**
**LIFTING-LINE SOLUTION FOR A SYMMETRICAL THIN WING IN GROUND EFFECT**
A. PLOTKIN (San Diego State University, CA) and C. H. TAN AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1193, 1194. refs

A lifting-line solution is presented for the problem of the aerodynamic characteristics of a thin wing in ground effect which is easier to obtain than previous numerical solutions, while furnishing reasonable accuracy for the cases of large aspect ratio wings. The effect of thickness on lift is considered in both the lifting line and vortex lattice formulations. O.C.

**A86-44875#**
**INTEGRATION OF SINGULAR FUNCTIONS ASSOCIATED WITH LIFTING SURFACE THEORY**
B. VAN NIEKERK (Stanford University, CA) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1194-1196. refs
(Contract AF-AFOSR-84-0099)

A simple quadrature rule directly applicable to subsonic aerodynamic problems is presented whose main advantage is that it allows kernel function applications to be as conceptually simple as the vortex panel method; this is due to the fact that careful identification and treatment of singularities is unnecessary. The technique may be used to compute time-accurate transient aerodynamic loads on wings. O.C.

**A86-44879*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**TRANSIENT INDUCED DRAG**
D. WEIHS and J. KATZ (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1203-1205. refs

In the present treatment of the calculation of forces on a wing that is suddenly brought into motion at a constant speed, attention is given to the unsteady potential's contribution to the force balance. Total bound vorticity is produced at the initial impulse. The results obtained are independent of wing aspect ratio; as time increases, this effect on the drag force becomes smaller as the vortex emanating from the trailing edge is left behind. The second contributor to induced drag is the spanwise vorticity shedding that results from the spanwise load distribution of three-dimensional wings. This contribution grows with time as the length of the wake grows. O.C.

**A86-44880#**
**UNIFIED SUPERSONIC/HYPERSONIC SIMILITUDE FOR OSCILLATING WEDGES AND PLANE OGIVES**
K. GHOSH (Indian Institute of Technology, Kanpur, India) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1205-1207. refs

The unified supersonic/hypersonic similitude for a wedge and quasi-wedge first reported in abstract form by Ghosh (1983) is presented under the tentative assumption that streamlines are straight. For a steady wedge, the present similitude applies in a plane normal to the shock with exactitude for freestream Mach numbers greater than 1. For a quasi-wedge or an oscillating wedge, another constraint in addition to the Mach number restriction is required. In the hypersonic domain, both similitudes are valid. O.C.

**A86-44889*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AN APPROXIMATE MODEL OF VORTEX DECAY IN THE ATMOSPHERE**
G. C. GREENE (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 566-573. Previously cited in issue 22, p. 3223, Accession no. A85-47034. refs

**A86-44890#**
**PRESSURE LOADING ON CURVED LEADING EDGE WINGS IN SUPERSONIC FLOW**
M. E. VAUGHN, JR. (U.S. Army, Missile Command, Huntsville, AL) and J. E. BURKHALTER (Auburn University, AL) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 574-581. Research sponsored by Auburn University. Previously cited in issue 06, p. 801, Accession no. A82-17934. refs
(Contract DAAG29-78-G-0036)

**A86-44891#**
**COMPUTATION OF ROTOR BLADE FLOWS USING THE EULER EQUATIONS**
N. L. SANKAR, S. G. LEKOUDIS (Georgia Institute of Technology, Atlanta), and B. E. WAKE Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 582-588. Army-supported research. Previously cited in issue 03, p. 242, Accession no. A86-14455. refs

**A86-44979**
**CALCULATION OF THE POTENTIAL FLOW AROUND WING PROFILES WITH THE AID OF A CONTINUOUSLY DIFFERENTIABLE VORTEX DISTRIBUTION [BERECHNUNG DER POTENTIALSTROEMUNG UM TRAGFLUEGELPROFILE MIT HILFE EINER STETIG DIFFERENZIERBAREN WIRBELBELEGUNG]**
H. JAEGER (Stuttgart, Universitaet, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Dubrovnik, Yugoslavia, April 1-4, 1985) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 66, no. 4, 1986, p. T 228, T 229. In German.

The numerical calculation of the compressible potential flow by means of the field panel procedure involves a combination of a panel procedure with a source distribution of the flow region. The derivatives have to be determined by numerical differentiation. A description is provided of a panel procedure which makes it possible to calculate also the derivatives by a direct approach. The steady flow around a wing profile is considered for the case of an incompressible flow, taking into account a procedure discussed by Jaeger (1984). The occurring curvilinear integrals can be approximated by integrals which can be evaluated analytically. The results provided by the described procedure, involving the case of a continuously differentiable vorticity distribution, are compared with the results of a panel procedure of a higher order. G.R.

**A86-45054**

**NUMERICAL SOLUTION OF THE SUPERSONIC LAMINAR FLOW OVER A TWO-DIMENSIONAL COMPRESSION CORNER USING AN IMPLICIT APPROACH**

N. S. MADHAVAN and V. SWAMINATHAN (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 6, June 1986, p. 387-393. refs

Using an implicit numerical scheme similar to MacCormack's (1982), the unsteady Navier-Stokes equations are successfully solved for the supersonic laminar two-dimensional compression corner flow problem. A 70 percent reduction in computational time is demonstrated for a Courant-Friedrichs-Lewy (CFL) number of 5, and CFL numbers up to 15 could be used without loss of accuracy. An increase in memory requirement for the implicit scheme of the order of 20 percent was also found. R.R.

**A86-45189**

**THE CLASSICAL STREAMLINE CURVATURE METHOD IN THE SUPERSONIC RANGE - A NUMERICALLY ILL-POSED BOUNDARY VALUE PROBLEM**

G. SPINDLER (DFVLR, Institut fuer technische Physik, Stuttgart, West Germany) and H. PAETZOLD (Brown Boveri et Cie AG, Baden, Switzerland) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Mar.-Apr. 1986, p. 107-115. refs

A linear stability analysis of the streamline curvature method using a homogeneous (isentropic) flow model, produces a numerical stability condition, first encountered by Wilkinson. It sets an upper limit on the (relative) Mach number in the supersonic range depending on streamline curve fitting and aspect ratio of the computational grid. Numerical test calculations of the flow in an axially parallel annular duct show that beyond this limit small perturbations of the streamline positions grow. This indicates that convergence to the homogeneous solution can no longer be achieved. Analytical considerations yield infinitely many neighboring solutions in certain cases, proving that the underlying hyperbolic boundary value problem is not properly posed. It is demonstrated that the numerical instability is strongly related to the non-uniqueness of the supersonic flow field. The application of backward differences for the approximation of the streamline curvature is discussed from a mathematical point of view. Author

**A86-45190**

**THE WING TIP VORTEX SYSTEM IN A STARTING FLOW**

P. FREYMUTH, F. FINAISH, and W. BANK (Colorado, University, Boulder) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Mar.-Apr. 1986, p. 116-118. refs

(Contract AF-AFOSR-81-0037)

The vortex system of a rectangular wing tip is visualized in a starting flow of constant acceleration. The system consists of a pair of vortices: one is fed from pressure side vorticity, the other from suction side vorticity. The vortices connect to each other at the corner between leading edge and tip. Author

**A86-45345**

**SCHEME FOR CALCULATING AN ALMOST-ASYMMETRIC GAS FLOW AND SUPERSONIC FLOW PAST THE END OF A CYLINDER AT A SMALL ANGLE OF ATTACK [SKHEMA RASCHETA BLIZKOGO K OSESIMMETRICHNOMU TECHENIIA GAZA I SVERKHZVUKOVOE OBTEKANIE TORTSA TSILINDRA POD NEBOL'SHIM UGLOM ATAKI]**

E. F. ZHIGALKO Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 26, June 1986, p. 951-954. In Russian.

A finite-difference scheme is developed for the approximate calculation of almost-asymmetric flows. The scheme is based on the large-particle method with trigonometric interpolation with respect to the meridional angle. The effectiveness of the scheme is demonstrated on the example of supersonic flow past the end of a circular cylinder at a small angle of attack. B.J.

**A86-45410*#** Massachusetts Inst. of Tech., Cambridge.

**ACTIVE SUPPRESSION OF COMPRESSOR INSTABILITIES**

A. H. EPSTEIN, J. E. FFOWCS WILLIAMS, and E. M. GREITZER (MIT, Cambridge, MA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. NASA-supported research. refs

(AIAA PAPER 86-1914)

A strategy is proposed for controlling aerodynamic instabilities which limit the useful range of both axial and centrifugal turbomachines. Both local and global instabilities (incipient rotating stall and surge) are analyzed. A theory is developed which shows how an additional disturbance, driven from real time data measured within the machine, can be generated so as to realize a device with characteristics fundamentally different from those of the turbomachine without control; for the particular compressor analyzed, the control led to a 20 percent increase in the extent of the stable operating range. The use of structural dynamics to enhance stability is also discussed. K.K.

**A86-45411#**

**CONTROL OF THE DISCRETE VORTICES FROM A DELTA WING**

M. GAD-EL-HAK and R. F. BLACKWELDER (Flow Research Co., Kent, WA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs

(Contract F49620-85-C-0131)

(AIAA PAPER 86-1915)

The modulation of shedding and pairing of discrete vortices is examined. The injection of a secondary fluid is utilized to control the development and strength of the bound-leading-edge vortices on delta wings. Flow visualization and wind tunnel tests were conducted in order to characterize the flow field around a delta wing. A delta wing with a sharp leading edge and a sweep of 60 deg was used in the towing tank and a delta-wing model with a root chord of 40 cm, a 60 deg sweep angle, and a sharp leading edge was employed in the wind tunnel tests. The procedure for perturbing the shear layer at the leading edge of the delta wing is described. The rms, spectral distribution, auto- and cross-correlations, and the probability density function of the velocity field are calculated using the instanteous velocity signal. The effects of the leading edge on the excitations of the shear layer are investigated. The data reveal that the maximum amount of variations in the leading edge vortices occurs when the perturbation frequency is a subharmonic of the natural shedding frequency of the unperturbed wing and when the injection/suction speed is about the same order of magnitude as the ambient velocity. I.F.

**A86-45413*#** California Univ., Los Angeles.

**AN EXPERIMENTAL INVESTIGATION OF WING TIP TURBULENCE WITH APPLICATIONS TO AEROSOUND**

S. A. MCINERNY, W. C. MEECHAM (California, University, Los Angeles), and P. T. SODERMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 21 p. refs
(AIAA PAPER 86-1918)

Wind tunnel tests were carried out to measure the turbulence characteristics of flow in the wing tip region of a blunt tipped NACA 0012 airfoil at 16-, 12-, and 6-deg angles of attack and 75-, 55-, and 35-m/s flow speeds. Results suggest the presence of a well organized turbulence structure with a peak Strouhal number 0.8 to 1.1 based on the wing thickness. At positions near the primary tip vortex on the upper wing surface, high frequency turbulence of lesser intensity was measured. Near-far field correlations reveal that the well-ordered tip turbulence and the separation region surface on the upper surface both radiate significant levels of far field sound. K.K.

**A86-45428*#** Lockheed-Georgia Co., Marietta.

**COHERENT LARGE-SCALE STRUCTURES IN HIGH REYNOLDS NUMBER SUPERSONIC JET OF MACH NUMBER 1.4**

J. LEPICOVSKY, K. K. AHUJA, W. H. BROWN, and R. H. BURRIN (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs
(Contract NAS1-17442)
(AIAA PAPER 86-1941)

Large-scale coherent structures are found to exist in fully expanded shock free supersonic jets with Reynolds number 1.6 million and Mach number 1.4. The jet was excited by a weak upstream tone to extract the large-scale structures from the random turbulence. The most preferential excitation Strouhal number is found to be in the vicinity of 0.4, and the dependence of the large-scale structure phase velocity on the excitation Strouhal number shows a similar trend to that found for subsonic acoustically excited jets. R.R.

**A86-45485#**

**FEATURES OF DISCRETE TONES GENERATED BY JET FLOWS OVER COANDA SURFACES**

P. W. CARPENTER, D. W. BRIDSON, and P. N. GREEN (Exeter, University, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. Research supported by the British Petroleum Co., PLC and SERC. refs
(AIAA PAPER 86-1865)

The paper presents the results of an experimental investigation of supersonic jet flows over axisymmetric Coanda surfaces. A description of the principal features of the flow fields is given based on extensive flow-visualization studies. Acoustic measurements were carried out both in the near and far field; typical results are presented and discussed. Simple computer simulations of the acoustic near field have been carried out for three different theoretical models in an attempt to identify the dominant mechanism for the generation of discrete tones in such flows. Author

**A86-45494*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMICS VIA ACOUSTICS - APPLICATION OF ACOUSTIC FORMULAS FOR AERODYNAMIC CALCULATIONS**

F. FARASSAT (NASA, Langley Research Center, Hampton, VA) and M. K. MYERS (George Washington University, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs
(AIAA PAPER 86-1877)

Prediction of aerodynamic loads on bodies in arbitrary motion is considered from an acoustic point of view, i.e., in a frame of reference fixed in the undisturbed medium. An inhomogeneous wave equation which governs the disturbance pressure is constructed and solved formally using generalized function theory. When the observer is located on the moving body surface there results a singular linear integral equation for surface pressure. Two different methods for obtaining such equations are discussed. Both steady and unsteady aerodynamic calculations are considered. Two examples are presented, the more important being an application to propeller aerodynamics. Of particular interest for numerical applications is the analytical behavior of the kernel functions in the various integral equations. Author

**A86-45702#**

**MORE ACCURATE SIMULATIONS OF WHOLE AIRCRAFT**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 12, 13.

A full, exact Euler equation simulation of an entire aircraft has been demonstrated for the first time. Previously tradeoffs had to be made: accurate simulation of only a wing for example or greatly simplified simulation of the whole aircraft; in either case, validating wind-tunnel tests of models were required with the incumbent problems of choosing appropriate scaling factors. The new method, by Princeton scientists T. J. Baker, A. Jameson, and N. P. Wetherhill, uses an unstructured grid - one without a set of coordinates. A set of points is built, working outward from each aircraft surface, the points being in the form of an array of tetrahedra (four triangles joined together). A new algorithm was devised to work well without coordinates, so that the grid is defined by each edge of a triangle and the two points opposite it. The simulation program balances energy flow into and out of the two triangles so defined. Bookkeeping is minimized and the program runs just as fast as more approximate methods. In the first demonstration of the program, pressures were calculated on a Boeing 747 airframe, based on 12,000 points; adequate accuracy would require taking 500,000 points and this simulation would require several hours on a Cray MXMP computer (comparable with run times of other simulations). Such simulations will permit engineers not only to develop more intelligent designs prior to wind-tunnel testing but also to focus on problem areas revealed by simulations. D.H.

**A86-46004**

**SPIRAL VORTEX FLOW OVER A SWEPT-BACK WING**

D. I. A. POLL (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, May 1986, p. 185-199. Research supported by the Ministry of Defence (Procurement Executive). refs

An experimental investigation has been performed to study the formation and development of spiral vortex flow over a swept-back wing. An aerofoil section with three alternative leading edge shapes was tested at sweep angles ranging from 0 to 56 deg for unit Reynolds numbers of 1,000,000/m and 2,000,000/m. The principal diagnostic tool was the surface oil-flow visualization technique supplemented by pressure distribution measurements in certain cases. No spiral vortex flow was observed for sweep angles of 0 and 15 deg but at higher sweep angles the oil-flows indicated that there were three different mechanisms for the formation of spiral vortices. The angle of incidence at the onset of vortex flow, and the mechanism responsible for its formation, were found to depend upon the sweep angle, the leading edge shape and the Reynolds number. It was also noted that the larger the leading edge radius, the greater the dependence upon Reynolds number. However, comparison with other work suggests that Reynolds number, incidence and sweep angle alone are insufficient to determine the type of spiral vortex flow occurring on a given wing. Author

**A86-46152#**

**VISCOUS-INVISCID INTERACTION SOLVERS AND COMPUTATION OF HIGHLY SEPARATED FLOWS**

J. C. LE BALLEUR (ONERA, Chatillon-sous-Bagneux, France) (NASA Institute for Computer Applications in Science and Engineering, Conference on Vortex Dominated Flows, Hampton, VA, July 9, 10, 1985) ONERA, TP, no. 1986-4, 1986, 35 p. refs
(ONERA, TP NO. 1986-4)

The use of indirect viscous-inviscid solvers based on interacting-defect integral equations to calculate flows with massive separation at the viscous or inviscid scale is examined, summarizing

the results of the author's recent numerical investigations. The derivation of the model equations is explained, and results for steady shock-wave/boundary-layer interactions, transonic unsteady separation, high-lift and stalled airfoils, and airfoils with defected spoilers are presented graphically.
T.K.

**A86-46171#**

### MODELING THREE-DIMENSIONAL FLOWS IN TERMS OF VISCOUS-INVISCID INTERACTION BY MEANS OF THE MSZ METHOD [CALCUL D'ECOULEMENTS TRIDIMENSIONNELS PAR INTERACTION VISQUEUX-NON VISQUEUX UTILISANT LA METHODE 'MZM']

M. LAZAREFF and J. C. LE BALLEUR (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium on Applications of Computational Fluid Dynamics in Aeronautics, Aix-en-Provence, France, Apr. 7-11, 1986) ONERA, TP, no. 1986-29, 1986, 16 p. In French. refs
(ONERA, TP NO. 1986-29)

A multi-zonal marching (MZM) method for solving systems of hyperbolic equations governing viscous fluid layers and modeling turbulent velocity profiles is extended to modeling three-dimensional separated flows over swept wings. The flow equations for a viscous fluid are decomposed into two-dimensional deficit equations for the viscous layer, equations for a perfect fluid, and equations for strong coupling. The concept of thin layers is applied in decomposing the numerical operators before coupling. Defining the viscous deficit equations in closed integral form permits retaining the hyperbolic form of the set of equations and generating a MacCormack space marching solution. Sample results are provided from modeling viscosity by coupling on a transonic wing, the boundary layer on an ellipsoid of revolution and a flattened ellipsoid at 60 deg angles of attack, and of the boundary layer on a glider geometry at a 30 deg angle of attack and 10 deg of sideslip.
M.S.K.

**A86-46185#**

### 10 YEARS OF ROTOR FLOWS STUDIES AT ONERA - STATE OF THE ART AND FUTURE STUDIES

A. DESOPPER, P. LAFON, P. CERONI, and J. J. PHILIPPE (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1986-49, 1986, 12 p. refs
(ONERA, TP NO. 1986-49)

For about 10 years now, at the Aerodynamics Department of ONERA, experimental and theoretical studies have been performed in order to improve the capability to perform accurate measurements as well as to predict the characteristics of the flow around a helicopter blade. The different phases of the experimental work and analytical studies concerning blade tip planform effects are presented and the main results are analyzed. The results demonstrate that it is possible for high speed rotor blades to define new blade tip shapes that minimize some of the problems due to transonic flows such as the increase of power required, of vibration level or of impulsive noise generated by the rotor. Finally, future studies planned to study the difficult problem of aeroelastic optimization are outlined.
Author

**A86-46316*#** United Technologies Research Center, East Hartford, Conn.

### THREE-DIMENSIONAL INVISCID FLOW IN MIXERS. II - ANALYSIS OF TURBOFAN FORCED MIXERS

T. J. BARBER (United Technologies Research Center, East Hartford, CT), G. L. MULLER, S. M. RAMSAY (Pratt and Whitney, East Hartford, CT), and E. M. MURMAN (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, July-Aug. 1986, p. 339-344. refs
(Contract NAS3-23039)

A small disturbance formulation for the three-dimensional potential analysis of the inviscid flow over a turbofan forced mixer configuration in which the governing equations are reduced by means of a flux volume formulation along a Cartesian grid is presently extended to include the effects of power addition within the potential formulation. Calculations are presented for practical turbofan mixer designs, and comparison calculations are also given with measured surface pressure distributions and measured axial velocity profiles.
O.C.

**A86-46415#**

### NUMERICAL CALCULATIONS OF INVISCID TRANSONIC FLOWS OVER WINGS

Z. CHEN, F. YAO, and Y. ZHANG (China Aerodynamics Research and Development Center, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, June 1986, p. 184-192. In Chinese, with abstract in English. refs

A numerical method for calculating steady inviscid transonic flows over wings is introduced. The full potential equation is chosen as the mathematical model. The infinite physical domain is transformed to a finite computing domain, and the swept wing is transformed to a rectangular wing using proper mathematical transformation. The equation is discretized in the computing domain using a mixed finite scheme, and the line-relaxation method is used for solving the resulting nonlinear algebraic equation. Successively refining, the mesh makes the calculation very economical.
Author

**A86-46793*** Massachusetts Inst. of Tech., Cambridge.

### HIGH RESOLUTION SOLUTIONS OF THE EULER EQUATIONS FOR VORTEX FLOWS

E. M. MURMAN, K. G. POWELL (MIT, Cambridge, MA), and A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: Progress and supercomputing in computational fluid dynamics; Proceedings of U.S.-Israel Workshop, Jerusalem, Israel, December 1984 . Boston, MA, Birkhaeuser, 1985, p. 93-113. Research supported by Flygtekniska Forsoksanstalten. refs
(Contract NAG1-358)

Solutions of the Euler equations are presented for M = 1.5 flow past a 70-degree-swept delta wing. At an angle of attack of 10 degrees, strong leading-edge vortices are produced. Two computational approaches are taken, based upon fully three-dimensional and conical flow theory. Both methods utilize a finite-volume discretization solved by a pseudounsteady multistage scheme. Results from the two approaches are in good agreement. Computations have been done on a 16-million-word CYBER 205 using 196 x 56 x 96 and 128 x 128 cells for the two methods. A sizable data base is generated, and some of the practical aspects of manipulating it are mentioned. The results reveal many interesting physical features of the compressible vortical flow field and also suggest new areas needing research.
Author

**N86-29765*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### TRANSONIC NAVIER-STOKES WING SOLUTION USING A ZONAL APPROACH. PART 1: SOLUTION METHODOLOGY AND CODE VALIDATION

J. FLORES, T. L. HOLST, U. KAYNAK (Sterling Software, Palo Alto, Calif.), K. GUNDY, and S. D. THOMAS Apr. 1986 2 p Presented at the AGARD Symposium on Applications of Computational Fluid Dynamics in Aeronautics, Aix En Provence, France, 7-10 Apr. 1986
(NASA-TM-88248; A-86206; NAS 1.15:88248) Avail: NTIS HC A02/MF A01 CSCL 01A

A fast diagonalized Beam-Warming algorithm is coupled with a zonal approach to solve the three-dimensional Euler/Navier-Stokes equations. The computer code, called Transonic Navier-Stokes (TNS), uses a total of four zones for wing configurations (or can be extended to complete aircraft configurations by adding zones). In the inner blocks near the wing surface, the thin-layer Navier-Stokes equations are solved, while in the outer two blocks the Euler equations are solved. The diagonal algorithm yields a speedup of as much as a factor of 40 over the original algorithm/zonal method code. The TNS code, in addition, has the capability to model wind tunnel walls. Transonic viscous solutions are obtained on a 150,000-point mesh for a NACA 0012 wing. A three-order-of-magnitude drop in the L2-norm of the residual requires approximately 500 iterations, which takes about 45 min of CPU time on a Cray-XMP processor. Simulations are also conducted for a different geometrical wing called WING C. All cases show good agreement with experimental data. Author

**N86-29766*#** Kansas Univ. Center for Research, Inc., Lawrence.

**AN INVESTIGATION OF TIP PLANFORM INFLUENCE ON THE AERODYNAMIC LOAD CHARACTERISTICS OF A SEMI-SPAN, UNSWEPT WING AND WING-TIP Final Technical Report**

J. M. VANAKEN Dec. 1985 83 p

(Contract NCC2-112)

(NASA-CR-177110; NAS 1.26:177110; CRINC-5171-1) Avail: NTIS HC A05/MF A01 CSCL 01A

A semi-span wing, equipped with an interchangeable tip, which was varied in planform and size was examined. Total wing aerodynamic loading was obtained from the wind tunnel scale system. The wing tip was mounted on a separate six-component strain gauge balance, which provided the aerodynamic loads on the tip. The tests were accomplished in the NASA Ames 7 x 10 foot Wind Tunnel at a Mach number of 0.178. The aerodynamic load characteristics of the wing and of the tip were presented with the tip at several incidence angles relative to the wing inboard section. B.G.

**N86-29768*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

**ANALYTICAL INVESTIGATION OF ROTOR WAKE FORMATION AND GEOMETRY Progress Report, 15 Apr. - 15 Oct. 1985**

R. MILLER and E. M. MURMAN 16 Jan. 1986 21 p

(Contract NAG2-275)

(NASA-CR-177032; NAS 1.26:177032) Avail: NTIS HC A02/MF A01 CSCL 01A

A number of refinements in the computer code were worked out and tested. Three codes have been written to date. One program is for an isolated wing and is being used to compare with data for the vortex wake (Weston). The second code is for an isolated wing with a streamwise vortex passing above it. This program is being used to validate the computational procedure for incorporating the vortex into the Euler equation calculations. The third program is the hovering rotor code which is the overall objective of the research. The optimization calculations for a hovering helicopter rotor have been completed. Author

**N86-29769*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**AN EXPERIMENTAL AND ANALYTICAL METHOD FOR APPROXIMATE DETERMINATION OF THE TILT ROTOR RESEARCH AIRCRAFT ROTOR/WING DOWNLOAD Final Report, 30 May 1984 - 30 Nov. 1985**

D. E. JORDON, W. PATTERSON, and D. R. SANDLIN Nov. 1985 116 p

(Contract NCC2-259)

(NASA-CR-176970; NAS 1.26:176970) Avail: NTIS HC A06/MF A01 CSCL 01A

The XV-15 Tilt Rotor Research Aircraft download phenomenon was analyzed. This phenomenon is a direct result of the two rotor wakes impinging on the wing upper surface when the aircraft is in the hover configuration. For this study the analysis proceeded along tow lines. First was a method whereby results from actual hover tests of the XV-15 aircraft were combined with drag coefficient results from wind tunnel tests of a wing that was representative of the aircraft wing. Second, an analytical method was used that modeled that airflow caused gy the two rotors. Formulas were developed in such a way that acomputer program could be used to calculate the axial velocities were then used in conjunction with the aforementioned wind tunnel drag coefficinet results to produce download values. An attempt was made to validate the analytical results by modeling a model rotor system for which direct download values were determinrd.. Author

**N86-29770*#** Iowa State Univ. of Science and Technology, Ames. Coll. of Engineering.

**VORTEX SHEET MODELING WITH HIGHER ORDER CURVED PANELS Ph.D Thesis Final Technical Report**

M. G. NAGATI 1985 115 p

(Contract NCC2-19)

(NASA-CR-176971; NAS 1.26:176971) Avail: NTIS HC A06/MF A01 CSCL 01A

A numerical technique is presented for modeling the vortex sheet with a deformable surface definition, along which a continuous vortex strength distribution in the spanwise direction is applied, so that by repeatedly modifying its shape, its true configuration is approached, in the proximity of its generating wing. Design problems requiring the inclusion of a realistic configuration of the vortex sheet are numerous. Examples discussed include: control effectiveness and stability derivatives, longitudinal stability, lateral stability, canards, propellers and helicopter rotors, and trailing vortex hazards. B.G.

**N86-29771*#** Oklahoma State Univ., Stillwater. School of Mechanical and Aerospace Engineering.

**CORRELATION OF TRANSONIC-CONE PRESTON-TUBE DATA AND SKIN FRICTION Final Report, Nov. 1980 - May 1984**

A. S. ABU-MOSTAFA and T. D. REED May 1984 104 p

(Contract NAG2-76)

(NASA-CR-176902; NAS 1.26:176902) Avail: NTIS HC A06/MF A01 CSCL 01A

Preston-tube measurements obtained on the Arnold Engineering Development Center (AEDC) Transition Cone have been correlated with theoretical skin friction coefficients in transitional and turbulent flow. This has been done for the NASA Ames 11-Ft Transonic Wind Tunnel (11 TWT) and flight tests. The developed semi-empirical correlations of Preston-tube data have been used to derive a calibration procedure for the 11 TWT flow quality. This procedure has been applied to the corrected laminar data, and an effective freestream unit Reynolds number is defined by requiring a matching of the average Preston-tube pressure in flight and in the tunnel. This study finds that the operating Reynolds number is below the effective value required for a match in laminar Preston-tube data. The distribution of this effective Reynolds number with Mach number correlates well with the freestream noise level in this tunnel. Analyses of transitional and turbulent data, however, did not result in effective Reynolds numbers that can be correlated with background noise. This is a result of the fact that vorticity fluctuations present in transitional and turbulent boundary layers dominate Preston-tube pressure fluctuations and, therefore, mask the tunnel noise effects. So, in order to calibrate the effects of noise on transonic wind tunnel tests only laminar data should be used, preferably at flow conditions similar to those in flight tests. To calibrate the effects of transonic wind-tunnel noise on drag measurements, however, the Preston-tube data must be supplemented with direct measurements of skin friction. M.G.

**N86-29772*#** Iowa State Univ. of Science and Technology, Ames. Dept. of Aerospace Engineering.

**NUMERICAL COMPUTATION OF VISCOUS FLOW AROUND BODIES AND WINGS MOVING AT SUPERSONIC SPEEDS Final Report, 15 Nov. 1971- 31 Mar. 1984**

J. C. TANNEHILL Apr. 1984 21 p

(Contract NGR-16-002-038)

(NASA-CR-176903; NAS 1.26:176903; ISU-ERI-AMES-84483; CFD-9) Avail: NTIS HC A02/MF A01 CSCL 01A

Research in aerodynamics is discussed. The development of equilibrium air curve fits; computation of hypersonic rarefield leading edge flows; computation of 2-D and 3-D blunt body laminar flows with an impinging shock; development of a two-dimensional or axisymmetric real gas blunt body code; a study of an over-relaxation procedure forthe MacCormack finite-difference scheme; computation of 2-D blunt body turbulent flows with an impinging shock; computation of supersonic viscous flow over delta wings at high angles of attack; and computation of the Space Shuttle Orbiter flowfield are discussed. Author

**N86-29773*#** Texas A&M Univ., College Station. Dept. of Aerospace Engineering.

**EXPERIMENTAL AND THEORETICAL STUDY OF PROPELLER SPINNER/SHANK INTERFERENCE M.S. Thesis**

C. C. CORNELL May 1986 143 p
(Contract NAS3-272)
(NASA-CR-176954; NAS 1.26:176954) Avail: NTIS HC A07/MF A01 CSCL 01A

A fundamental experimental and theoretical investigation into the aerodynamic interference associated with propeller spinner and shank regions was conducted. The research program involved a theoretical assessment of solutions previously proposed, followed by a systematic experimental study to supplement the existing data base. As a result, a refined computational procedure was established for prediction of interference effects in terms of interference drag and resolved into propeller thrust and torque components. These quantities were examined with attention to engineering parameters such as two spinner finess ratios, three blade shank forms, and two/three/four/six/eight blades. Consideration of the physics of the phenomena aided in the logical deduction of two individual interference quantities (cascade effects and spinner/shank juncture interference). These interference effects were semi-empirically modeled using existing theories and placed into a compatible form with an existing propeller performance scheme which provided the basis for examples of application. Author

**N86-29776*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PSEUDO-TIME ALGORITHMS FOR THE NAVIER-STOKES EQUATIONS**

R. C. SWANSON and E. TURKEL (Tel-Aviv Univ. (Israel).) May 1986 33 p
(Contract NAS1-17070; NAS1-18107)
(NASA-CR-178127; ICASE-86-37; NAS 1.26:178127) Avail: NTIS HC A03/MF A01 CSCL 01A

A pseudo-time method is introduced to integrate the compressible Navier-Stokes equations to a steady state. This method is a generalization of a method used by Crocco and also by Allen and Cheng. We show that for a simple heat equation that this is just a renormalization of the time. For a convection-diffusion equation the renormalization is dependent only on the viscous terms. We implement the method for the Navier-Stokes equations using a Runge-Kutta type algorithm. This permits the time step to be chosen based on the inviscid model only. We also discuss the use of residual smoothing when viscous terms are present. Author

**N86-29777*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AN ENTROPY CORRECTION METHOD FOR UNSTEADY FULL POTENTIAL FLOWS WITH STRONG SHOCKS**

W. WHITLOW, JR., M. M. HAFEZ (California Univ., Davis.), and S. J. OSHER (California Univ., Los Angeles.) Jun. 1986 14 p
(NASA-TM-87769; NAS 1.15:87769) Avail: NTIS HC A02/MF A01 CSCL 01A

An entropy correction method for the unsteady full potential equation is presented. The unsteady potential equation is modified to account for entropy jumps across shock waves. The conservative form of the modified equation is solved in generalized coordinates using an implicit, approximate factorization method. A flux-biasing differencing method, which generates the proper amounts of artificial viscosity in supersonic regions, is used to discretize the flow equations in space. Comparisons between the present method and solutions of the Euler equations and between the present method and experimental data are presented. The comparisons show that the present method more accurately models solutions of the Euler equations and experiment than does the isentropic potential formulation. Author

**N86-29778#** Montana State Univ., Missoula. Supersonic Wind Tunnel Lab.

**BOUNDARY LAYER STABILITY MEASUREMENTS OVER A FLAT PLATE AT MACH 3 Final Report**

A. DEMETRIADES Nov. 1985 203 p
(Contract AF-AFOSR-0267-80)
(AD-A166188; SWT-TR-85-1; AFOSR-86-0056TR) Avail: NTIS HC A10/MF A01 CSCL 20D

Amplification of natural disturbances in a flat plate laminar boundary layer at edge Mach number 3 have been measured in a supersonic wind tunnel with and without turbulent sidewall boundary layers. Detailed flowfield measurements were made to define the self-similar region and the point where the velocity profile first departs from the Blasius theory. The first instability mode was detected with a minimum critical momentum Reynolds number of 190 and a maximum amplified frequency of 0.000225. Amplification rates for this mode agree with the available theoretical predictions, and its low-frequency, low-R region is not as distorted by monotonic amplification as previously thought. A second, very prominent and extensive instability was found which extends to much higher frequencies beyond F = 0.00035 and which dominates the pretransitional flow. The neutral branch location of this mode associates it with the second instability mode found in hypersonic flow and serves to clarify and present a stability diagram rational over the M = 0 to 8 range. The overall amplitude gain before the first departure is still confined to low frequencies with the first mode contributing little net gain, the combined first-second modes contributing a gain of about 3, while an additional factor of 5 to 10 is provided by a mechanism active near the leading edge and apparently consistent with Mack's forcing-stability approach. GRA

**N86-29782#** Grumman Aerospace Corp., Bethpage, N.Y. Research and Development Center.

**AN INVESTIGATION OF TURBULENCE MECHANISMS IN V/STOL UPWASH FLOW FIELDS Final Report, Mar. 1982 - Jun. 1985**

B. GILBERT 15 Sep. 1985 94 p
(Contract F49620-82-C-0025)
(AD-A166286; RE-707; AFOSR-86-0096TR) Avail: NTIS HC A05/MF A01 CSCL 20D

This report presents results of an experimental investigation of the abnormally high turbulent mixing layer growth rate characteristics found in the upwash regions of V/STOL flows in ground effect. The fundamental turbulent V/STOL upwash mechanisms were investigated in increasingly more complex flow configurations. Most of this study uses the two-dimensional upwash formed by the collision of opposed two-dimensional wall jets. Initial parameters used to characterize the upwash formation were identified as the maximum wall jet velocity and wall jet half velocity width. Upwash measurements were taken in flows formed from equal wall jets with the same maximum velocities and equal wall jets with the same half widths. While mixing layer growth rates were larger than those found in a free two-dimensional jet, these values were less than those previously reported. An explanation based on non-similarity conditions in the flow is offered. Abnormally high turbulence levels reported by other investigators were not found. The increased growth rate seem to be a direct effect of the head-on collision process. There is an indication that in the far field the upwash growth characteristics are approaching those found in free jets which has profound implications to the turbulence modelers. GRA

**N86-29786#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Struct

**INFLUENCE OF THE ANGLE OF ATTACK AND FLUTTER ON THE LIFT OF A SUPERCRITICAL WING. COMPARISON BETWEEN THEORY AND EXPERIMENT Final Report [INFLUENCE DE L'INCIDENCE ET DU VRILLAGE SUR LE FLOTTEMENT D'UNE AILE SUPERCRITIQUE. COMPARAISON THEORIE-EXPERIENCE]**

R. DESTUYNDER and A. GRAVELLE Dec. 1985 40 p In FRENCH
(Contract STPA-84-95-015)
(ONERA-RT-24/3064-RY-044-R; ESA-86-97276) Avail: NTIS HC A03/MF A01

Variations of the critical lift velocity in transonic flow (Mach 0.8) was studied. A first method is based on a linear computation of the corrections to perform on wind tunnel steady flow pressure measurements. A second nonlinear method is based on the analysis of small perturbations which take in account the deformations and the exact profile of the model. The comparison shows that both methods are close to the experimental results. ESA

**N86-30628#** Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.

**TRANSONIC EQUIVALENT STRIP METHOD FOR AEROELASTIC APPLICATIONS**

D. D. LIU, Y. F. KAO, and K. Y. FUNG (Arizona Univ., Tucson) *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 17-32 1985 Sponsored by DTNSRDC/NAVAIR
Avail: NTIS HC A99/MF E03

For unsteady flow computations of arbitrary wing planforms including control surfaces, a method based on the transonic equivalent strip (TES) model is developed. It consists of two consecutive correction steps to a given unsteady two-dimensional code. The latter can be a time-linearized transonic code or a nonlinear one such as LTRAN2 code. The mean-flow correction step involves an equivalent airfoil design procedure; the spanwise phase correction step accounts for the effects of acoustic wave propagation in three dimensions. Computed results using the TES method are compared with those obtained by methods such as versions of XTRAN3 code, Isogai's full potential code, and measured data. Computed cases include the Northrop F-5 wing in pitching oscillation, the AGARD standard RAE wing with an oscillating flap, and the LANN wing in pitching oscillation. ESA

**N86-30629#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

**CALCULATION OF THREE-DIMENSIONAL TRANSONIC POTENTIAL FLOWS BY A FIELD PANEL METHOD**

R. VOSS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 33-46 1985
Avail: NTIS HC A99/MF E03

A calculation method for three dimensional transonic flows around oscillating wings is described. It solves the time-linearized unsteady transonic small perturbation equation by an integral equation method with a field panel technique. In a computer code called PTRAN3, the field panel technique is combined with a finite difference method. Accuracy and computer costs of the code are acceptable for routine flutter applications. Results for applications to pitching motions of a rectangular wing and two swept wings (LANN wing and F5 wing) with high and low aspect ratio are shown. ESA

**N86-30631#** Fairchild Republic Div., Farmingdale, N. Y.

**EXACT CLOSED-FORM SOLUTIONS FOR NONLINEAR UNSTEADY TRANSONIC AERODYNAMICS**

G. A. OYIBO *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 71-78 1985
Avail: NTIS HC A99/MF E03

The existence of exact closed-form solutions for nonlinear unsteady aerodynamics is established. The full nonlinear unsteady velocity potential equations for an airfoil are considered. Evidence indicating why the traditional hodograph approach is ineffective for solving these equations is provided. A mapping scheme transforms these full nonlinear equations into the hodograph plane. Examination of the resulting hodograph equations reveals that by prescribing the Jacobian of the transformation, ab initio, the exact closed-form solutions can be obtained for the nonlinear unsteady aerodynamic characteristics of an airfoil in a potential flow. The shockless transonic results for inviscid analysis show trends that agree with previous data. Dips are observed in the pressure distributions as the free stream Mach number is varied. There are finite optimum reduced frequencies (Strouhal numbers) for the pressure distributions. This suggests a solution to the transonic dip problem associated with aeroelastic stability characteristics at transonic Mach numbers. ESA

**N86-30632#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.

**STEADY AND UNSTEADY PRESSURE DISTRIBUTION ON VARIOUS PROFILES IN SEPARATED SUBSONIC AND TRANSONIC FLOW**

H. TRIEBSTEIN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 99-119 1985
Avail: NTIS HC A99/MF E03

Steady, mean, and unsteady aerodynamic data were measured on two dimensional rectangular wings, one with a supercritical MBB-Va2 profile and one with a NACA 0012 in subsonic flow and another supercritical MBB-A3 profile in transonic flow. The measurements were performed to produce systematic results with respect to Mach number, reduced frequency, incidence (wing, spoiler, tab) and amplitude of oscillation, and for use in the development and assessment of subsonic and transonic codes. The higher harmonic parts of the unsteady pressure in the region of pressure jumps and flow separation are emphasized. The wind tunnels, test setups, wing configurations, electronic data recording and processing devices, and the measuring procedure are described. ESA

**N86-30633#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

**AN IMPROVED POTENTIAL GRADIENT METHOD FOR THE CALCULATION OF UNSTEADY AERODYNAMIC PRESSURES ON OSCILLATING WINGS IN SUPERSONIC FLOW**

F. Q. ZHANG and H. FOERSCHING *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 153-162 1985
Avail: NTIS HC A99/MF E03

A method to calculate pressure distributions on harmonically oscillating wings is presented. The method uses an integral variable substitution, by which the computer time is reduced considerably together with an improvement of computation accuracy, especially for low supersonic Mach numbers and high reduced frequencies. Comparisons with other methods and experimental results show quite satisfactory agreement. ESA

**N86-30634#** Tel-Aviv Univ. (Israel). Dept. of Solid Mechanics, Materials and Structures.

**AN EXACT FORMULATION OF THE UNSTEADY AERODYNAMIC THEORY OF LIFTING SURFACES UNDERGOING ARBITRARY SMALL MOTIONS IN A SUPERSONIC FLOW FIELD**

L. LIBRESCU *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 163-168 1985
Avail: NTIS HC A99/MF E03

The indirect theory of unsteady lifting surfaces is developed. The integral equation (IE) relating a known downwash distribution to an unknown pressure distribution is derived without any restriction on the time dependence of field variables. The IE for simple harmonic motions and arbitrary small motions starting from rest at a certain time are obtained. In the latter case, the theory of generalized functions is used to derive the appropriate integral equation, by incorporating the associated initial conditions, and by highlighting properties of the aerodynamic kernel such as causality. The relationship between the aerodynamic kernels in the time and frequency domains is established. The problem analyzed is useful in the evaluation of the structural response of flight vehicles as well as in the active control problem of aeroelastic response. ESA

**N86-30636#** Technische Univ., Brunswick (West Germany). Inst. fuer Stroemungsmechanik.

**APPLICATION OF UNSTEADY WING COLLOCATION METHODS TO CASCADES IN SUBSONIC FLOW**

A. KLOSE and B. LASCHKA *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 180-186 1985
Avail: NTIS HC A99/MF E03

A method to calculate the pressure distribution and unsteady forces on the blades of a flat plate cascade in subsonic flow during harmonic oscillation is presented. A collocation method as used in lifting surface theories for single airfoils was adapted to solve the cascade equation. Pressure distribution and aerodynamic forces for several values of stagger, reduced frequency, space-to-chord ratio, Mach number and interblade phase angle were calculated. The results were compared to published data. Significant differences are discovered. ESA

**N86-30638*#** California Univ., Berkeley. Dept. of Mechanical, Aerospace and Nuclear Enginee Ring.

**A NEW LOOK AT ARBITRARY MOTION UNSTEADY AERODYNAMICS AND ITS APPLICATION TO ROTARY-WING AEROELASTICITY**

P. P. FRIEDMANN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 194-210 1985
(Contract NAG2-209)
Avail: NTIS HC A99/MF E03 CSCL 01B

Research on arbitrary motion unsteady aerodynamics, emphasizing applications to rotary wing aeroelastic problems, is reviewed. Generalization of Greenberg's theory and its application to hingeless rotor aeroelastic stability; a technique for formulating finite state approximations to unsteady aerodynamic theories, suitable for fixed and rotary-wing applications, and its application to generalize Loewy's theory; comparison of fixed wing and rotary wing indicial response functions; influence of arbitrary motion aerodynamics, as represented by dynamic inflow on a helicopter in ground resonance; and comparison of dynamic inflow with arbitrary motion unsteady airfoil aerodynamics are covered. ESA

**N86-30639#** Shenyang Aircraft Corp. (China).

**EXPERIMENTAL TRANSONIC PRESSURE DISTRIBUTIONS OF A FLEXIBLE WING-AILERON MODEL AND COMPARISONS WITH RESULTS OF SEVERAL THEORETICAL METHODS**

D. GUAN, W. LIU, Z. GAO, and Y. ZHANG *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 211-218 1985
Avail: NTIS HC A99/MF E03

Analytical methods for the prediction of transonic load distribution due to large aileron deflection angle on a flexible wing were investigated. A 60 deg delta wing model with representative stiffness level and deflected aileron was tested in a high speed wind tunnel, and pressure distributions were measured. Second order transonic small disturbance theory, linearized aerodynamic theory, and an empirical method based on rigid model pressure distributions were used to calculate the load distribution. The empirical method seems more powerful. ESA

**N86-30640#** Northwestern Polytechnical Univ., Xian (China).

**CALCULATION OF THE LOAD DISTRIBUTION, AERODYNAMIC DERIVATIVES AND DYNAMIC CHARACTERISTICS OF QUASI-STATIC ELASTIC AIRCRAFT**

Q. LIU, C. WU, Z. JIAN, and K. WU *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 219-228 1985
Avail: NTIS HC A99/MF E03

A numerical method for predicting the aerodynamic characteristics of quasi-static elastic aircraft is presented. The method can be used to evaluate the load distribution, control surface efficiency, aerodynamic derivatives and dynamic properties at subsonic speed. The aerodynamic calculations are based on the Green's function method. In structure deformation calculations, the free-structure influence coefficient method is used to evaluate the deformation of the elastic aircraft in free flight. The calculations are carried out for a large elastic aircraft. Results on load distribution, elevator efficiency, longitudinal aerodynamic derivatives, frequency responses to elevator input, and other dynamic properties are compared with those of the same aircraft where the elastic effect is not considered. ESA

**N86-30659#** Fairchild Republic Div., Farmingdale, N. Y.

**ANISOTROPIC WING AEROELASTIC THEORIES WITH WARPING EFFECTS**

G. A. OYIBO and J. H. BERMAN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 434-440 1985
Avail: NTIS HC A99/MF E03

The influence of warping (spanwise axial constraints on wing twist) on anisotropic wing aeroelastic oscillations is investigated using a similarity rule approach. Results show that a high aspect ratio anisotropic wing could behave aeroelastically like a low aspect ratio wing and vice-versa. Similarity parameters derived in the analysis expose conditions for which this might happen. The analysis also indicates that the parameter that is currently used in determining when warping is important (or when not to use the St Venant's torsion theory) is inaccurate for anisotropic wings. The correct parameter is presented. ESA

**N86-30691*#** New York Univ., New York. Courant Mathematics and Computing Lab.

**THE METHOD OF COMPLEX CHARACTERISTICS FOR DESIGN OF TRANSONIC BLADE SECTIONS Research and Development Report**

M. R. BLEDSOE Jun. 1986 203 p
(Contract NAG2-345; DE-AC02-76ER-03077; NSF DMS-83-20430)
(NASA-CR-176978; NAS 1.26:176978; DOE/ER-03077/273)
Avail: NTIS HC A10/MF A01 CSCL 01A

A variety of computational methods were developed to obtain shockless or near shockless flow past two-dimensional airfoils. The approach used was the method of complex characteristics, which determines smooth solutions to the transonic flow equations based on an input speed distribution. General results from fluid mechanics are presented. An account of the method of complex characteristics is given including a description of the particular spaces and coordinates, conformal transformations, and numerical procedures that are used. The operation of the computer program COMPRES is presented along with examples of blade sections designed with the code. A user manual is included with a glossary to provide additional information which may be helpful. The computer program in Fortran, including numerous comment cards is listed. B.G.

**N86-30693*#** Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
**AERODYNAMIC DATA BANKS FOR CLARK-Y, NACA 4-DIGIT AND NACA 16-SERIES AIRFOIL FAMILIES Final Report**
K. D. KORKAN, J. CAMBA, III, and P. M. MORRIS Jan. 1986 272 p
(Contract NAS3-272)
(NASA-CR-176883; NAS 1.26:176883) Avail: NTIS HC A12/MF A01 CSCL 01A

With the renewed interest in propellers as means of obtaining thrust and fuel efficiency in addition to the increased utilization of the computer, a significant amount of progress was made in the development of theoretical models to predict the performance of propeller systems. Inherent in the majority of the theoretical performance models to date is the need for airfoil data banks which provide lift, drag, and moment coefficient values as a function of Mach number, angle-of-attack, maximum thickness to chord ratio, and Reynolds number. Realizing the need for such data, a study was initiated to provide airfoil data banks for three commonly used airfoil families in propeller design and analysis. The families chosen consisted of the Clark-Y, NACA 16 series, and NACA 4 digit series airfoils. The various component of each computer code, the source of the data used to create the airfoil data bank, the limitations of each data bank, program listing, and a sample case with its associated input-output are described. Each airfoil data bank computer code was written to be used on the Amdahl Computer system, which is IBM compatible and uses Fortran.
Author

**N86-30694*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**COMPARISON OF EXPERIMENTAL SURFACE PRESSURES WITH THEORETICAL PREDICTIONS ON TWIN TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLES**
J. R. CARLSON, O. C. PENDERGRAFT, JR., and J. R. BURLEY, II Aug. 1986 31 p Presented at the AIAA 4th Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986
(NASA-TM-87757; NAS 1.15:87757; AIAA-86-1803-CP) Avail: NTIS HC A03/MF A01 CSCL 01A

A three-dimensional subsonic aerodynamic panel code (VSAERO) was used to predict the effects of upper and lower external nozzle flap geometry on the external afterbody/nozzle pressure coefficient distributions and external nozzle drag of nonaxisymmetric convergent-divergent exhaust nozzles having parallel external sidewalls installed on a generic twin-engine high performance aircraft model. Nozzle static pressure coefficient distributions along the upper and lower surfaces near the model centerline and near the outer edges (corner) of the two surfaces were calculated, and nozzle drag was predicted using these surface pressure distributions. A comparison between the theoretical predictions and experimental wind tunnel data is made to evaluate the utility of the code in calculating the flow about these types of non-axisymmetric afterbody configurations. For free-stream Mach numbers of 0.60 and 0.90, the conditions where the flows were attached on the boattails yielded the best comparison between the theoretical predictions and the experimental data. For the Boattail terminal angles of greater than 15 deg., the experimental data for $M = 0.60$ and 0.90 indicated areas of separated flow, so the theoretical predictions failed to match the experimental data. Even though calculations of regions of separated flows are within the capabilities of the theoretical method, acceptable solutions were not obtained.
Author

**N86-30695*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**EXPERIMENTAL AND NUMERICAL RESULTS FOR A GENERIC AXISYMMETRIC SINGLE-ENGINE AFTERBODY WITH TAILS AT TRANSONIC SPEEDS**
J. R. BURLEY, II, J. R. CARLSON, and W. P. HENDERSON Aug. 1986 20 p Presented at the AIAA 4th Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986
(NASA-TM-87755; NAS 1.15:87755; AIAA-86-1797-CP) Avail: NTIS HC A02/MF A01 CSCL 01A

Static pressure measurements were made on the afterbody, nozzle and tails of a generic single-engine axisymmetric fighter configuration. Data were recorded at Mach numbers of 0.6, 0.9, and 1.2. NPR was varied from 1.0 to 8.0 and angle of attack was varied from -3 deg. to 9 deg. Experimental data were compared with numerical results from two state-of-the-art computer codes.
Author

**N86-30696*#** Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.
**NUMERICAL STUDIES OF POROUS AIRFOILS IN TRANSONIC FLOW Ph.D. Thesis. Final Report, 1 Jun. 1985 - 31 Aug. 1986**
C. Y. CHOW 1986 114 p
(Contract NCC2-355)
(NASA-CR-179655; NAS 1.26:179655) Avail: NTIS HC A06/MF A01 CSCL 01A

A numerical tool is constructed to examine the effects of a porous surface on transonic airfoil performance and to help understand the flow structure of passive shockwave/boundary layer interactions. The porous region is located near the shock with a cavity underneath it. This study is composed of two parts. Solved in the first part, with an inviscid-flow approach, is the transonic full-potential equation associated with transpiration boundary conditions which are obtained from porosity modeling. The numerical results indicate that a porous airfoil has a wave drag lower than that of a solid airfoil. The observed lambda-shock structure in the wind-tunnel testing can be predicted. Furthermore, the lift could be increased with an appropriate porosity distribution. In the second part of this work, the modified version of either an interactive boundary layer (IBL) algorithm or a thin-layer Navier-Stokes (TLNS) algorithm is used to study the outer flow, while a stream-function formulation is used to model the inner flow in the shallow cavity. The coupling procedure at the porous surface is based on Darcy's law and the assumption of a constant total pressure in the cavity. In addition, a modified Baldwin-Lomax turbulence model is used to describe the transpired turbulent boundary layer in the TLNS approach, while the Cebeci turbulence model is used in the IBL approach. According to the present analysis, a porous surface can reduce the wave drag appreciably, but can also increase the viscous losses. As has been observed experimentally, the numerical results indicate that the total drag is reduced at higher Mach numbers and increased at lower Mach numbers when the angles of attack are small. Furthermore, the streamline pattern of passive shock/boundary layer interaction are revealed.
Author

**N86-30697*#** Cornell Univ., Ithaca, N.Y. School of Mechanical and Aerospace Engineering.
**AERODYNAMICS OF ENGINE-AIRFRAME INTERACTION Annual Progress Report, 1 Oct. 1985 - 30 Sep. 1986**
D. A. CAUGHEY 30 Aug. 1986 29 p
(Contract NAG2-373)
(NASA-CR-179657; NAS 1.26:179657) Avail: NTIS HC A03/MF A01 CSCL 01A

The report describes progress in research directed towards the efficient solution of the inviscid Euler and Reynolds-averaged Navier-Stokes equations for transonic flows through engine inlets, and past complete aircraft configurations, with emphasis on the flowfields in the vicinity of engine inlets. The research focusses upon the development of solution-adaptive grid procedures for these problems, and the development of multi-grid algorithms in conjunction with both, implicit and explicit time-stepping schemes for the solution of three-dimensional problems. The work includes further development of mesh systems suitable for inlet and wing-fuselage-inlet geometries using a variational approach. Work during this reporting period concentrated upon two-dimensional problems, and has been in two general areas: (1) the development of solution-adaptive procedures to cluster the grid cells in regions of high (truncation) error;and (2) the development of a multigrid scheme for solution of the two-dimensional Euler equations using a diagonalized alternating direction implicit (ADI) smoothing algorithm. M.G.

**N86-30698*#** Vigyan Research Associates, Inc., Hampton, Va.
**PAN AIR APPLICATION TO THE F-106B**
F. GHAFFARI Aug. 1986 60 p
(Contract NAS1-17919)
(NASA-CR-178165; NAS 1.26:178165) Avail: NTIS HC A04/MF A01 CSCL 01A

The PAN AIR computer code was employed in the present study to investigate the aerodynamic effects of the various geometrical changes and flow conditions on a configuration similar to the F-106B half-airplane tested in the Langley 30x60-foot wind tunnel. The various geometries studied included two forebodies (original and shortened), two inlet flow conditions (open and closed) two vortex flap situations (off and on). The attached flow theoretical solutions were obtained for Mach number of 0.08 and angle of attack of 8 deg., 10 deg., 12 deg., and 14 deg. In general this investigation revealed that the shortening of the forebody or closing of the inlet produced only a small change in the overall aerodynamic coefficients of the basic F-106B configuration throughout the examined angles of attack. However, closing the inlet of the configuration resulted in a slightly higher drag level at low angles of attack. Furthermore, at and above 10 deg. angle of attack, it was shown that the presence of the vortex flap causes an increase in the total lift and drag. Also, these theoretical results showed the expected reduction in longitudinal stability level with addition of the vortex flap to the basic F-106B configuration. Author

**N86-30700#** Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
**AIR-ON DEMONSTRATION OF THE AEDC PWT TUNNEL 16T CAPTIVE TRAJECTORY SUPPORT SYSTEM Final Report, 21 Jul. - 26 Jul. 1985**
L. L. ARENDT (Calspan Field Services, Inc., Arnold AFS, Tenn.) Sep. 1985 68 p Prepared in cooperation with Calspan Field Service
(AD-A166888; AEDC-TSR-85-P17) Avail: NTIS HC A04/MF A01 CSCL 20D

An air-on demonstration of the Captive Trajectory Support (CTS) system was conducted in the AEDC Propulsion Wind Tunnel (16T). The test objectives were: (1) to demonstrate the structural integrity of the CTS system; (2) to demonstrate the ability of the CTS system to satisfactorily obtain grid and trajectory generation data for a typical store model in free stream and relative to a simulated (flat plate) aircraft in a dynamic wind tunnel environment; (3) to obtain a Mach number calibration for the Tunnel 16T Cart 2 (Multipurpose Cart) with the CTS system installed. The 1/4-scale Maximum Volume Bomb (MVB) was used to represent a typical store. Data were obtained at free-stream numbers from 0.6 to 1.6 and at various compressor ratios. GRA

# 03

# AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-44400**
**THE FIRE-HARD AIRLINER**
J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 129, May 17, 1986, p. 27-30.

The complex problems posed by airliner cabin fires are examined and the continuing search for even more fire-resistant materials is described. In 25 years the airlines have suffered about 50 cabin fires in the air, of which fewer than half have been fatal. This is a fatal cabin-fire rate of only one per 10,000,000 flights. Three tragic fires are described. At Riyadh in 1980, all 301 occupants of a Saudi TriStar died when a flashover of combustible gases ran through the cabin when engines and air conditioning were shut down after an emergency landing. In Manchester, England, British Airways 737 caught fire on takeoff; blazing fuel melted the fuelage and 55 of the 137 occupants died, most of them from hydrogen cyanide or carbon monoxide gases or 'black ash' emitted by burning cabin furnishings. Approaching Greater Cincinnati, in 1983, an Air Canada DC-9 had a fire aboard smoldering for almost 15 minutes before being discovered; during the emergency landing, acrid black smoke filled the cabin but it only ignited a minute after the doors and exits had been opened on landing; half of the 46 occupants died. A major question in fire hardening is whether to try to make cabin furnishing harder to ignite (noting that all plastics do burn) or to try to find materials that emit gases that are less toxic when they are burning. Topics covered include: plastic materials, wool, fireblockers, tests (Airbus and Boeing standards, FAA rulemaking - NPRM 85-10), and structure (aircraft skin, sidewalls, ceiling, windows, fuel tanks). D.H.

**A86-44777**
**1985 USAF EJECTION SUMMARY**
R. C. DELGADO (USAF, Directorate of Aerospace Safety, Norton AFB, CA) SAFE Journal, vol. 16, no. 2, Summer 1986, p. 16, 17.

An analysis of the USAF ejection statistics for the 58 crewmembers involved in escape-system-equipped aircraft mishaps during 1985 is presented. An 81 percent ejection survival rate from the 43 attempted ejections (the lowest number of ejections since 1950) is found. Six out of eight of the fatalities were due to out-of-envelope ejection, involving three in F-4s, two in a T-38, and one in an F-16. Specific ejection mishaps are discussed, and recommendations are made. R.R.

**A86-44701**
**AUTOMATIC INFLATION MODULATION (A.I.M.) PARACHUTE UP-DATE**
D. B. WEBB (Irvin Industries Canada, Ltd., Fort Erie) SAFE Journal, vol. 16, no. 2, Summer 1986, p. 38-45. refs

The current status of the AIM parachute and parachute system testing in each of the Martin Baker MK.12, the Stencel S4S and the McDonnell Douglas ACES II ejection seats is reviewed. The benefits of deploying the main canopy at the highest possible speed are discussed, together with the necessary structural integrity and inflation control requirements. Results of additional environmental testing of the stretch fabric used in the AIM canopy crown area (for relief of inflation loads) are included, which show that it closely follows the standard MIL-C-7020 parachute cloth results. Author

**A86-45757**
**SNIFFING OUT TROUBLE**
H. HOPKINS Flight International (ISSN 0015-3710), vol. 129, June 28, 1986, p. 24-26.

The 'Condor' contraband detector system is a mobile explosives and illegal drugs cargo inspection apparatus for use at airports against smugglers and terrorists. The entire system is contained in two installations through which cargo vehicles pass on a conveyor belt, with an inspection capacity of around 100 tonnes/hr. Luggage does not have to be unpacked for inspection. Condor is housed in a 30-ft-long trailer, and is currently priced at over 2 million pounds sterling. Operations are conducted by two personnel, one of whom works outside it on the actual sampling manipulations while the other is inside, monitoring the analysis functions. O.C.

**N86-29790#** National Transportation Safety Board, Washington, D. C.
**SAFETY RECOMMENDATION**
J. BURNETT 28 Mar. 1986 2 p
(NTSB-A-86-22; NTSB-A-86-23; REPT-4346/I-60A) Avail: NTIS HC A02/MF A01

On June 25, 1985, a Cessna Model 150 airplane, N704ZS, sustained substantial damage after a loss of engine power in flight forced the pilot to execute an emergency landing at Rushville, Missouri. The National Transportation Safety Board's investigation of the accident disclosed that the power loss occurred because a self-locking nut became disengaged from the bolt that connects the throttle cable rod end to the carburetor throttle arm, permitting the bolt to back out of the bolt hole. Since January 1, 1980, throttle linkages have become disconnected from carburetor throttle arms for similar reasons on seven other Cessna Model 150 airplanes. Additionally, the loss of connecting hardware has caused the separation of engine throttle or mixture controls on Cessna Model 152, 172, 177RG, A188, and U206 airplanes, resulting in six accidents, one incident, and eight service difficulty reports. Author

**N86-29791#** National Transportation Safety Board, Washington, D. C.
**NATIONAL TRANSPORTATION SAFETY BOARD SAFETY RECOMMENDATION**
7 Apr. 1986 6 p
(NTSB-4360/33) Avail: NTIS HC A02/MF A01

Problems that have been experienced by the Pratt & Whitney Aircraft JT8D-1 through -17AR engines are discussed. Thses problems include failures of combustion chambers, removable sleeve spacers in the high-pressure compressor, combustion chamber outer cases, second-stage low-pressure turbine disks, second-stage fan blades, and high-pressure and low-pressure turbine blades. Author

**N86-29792#** National Transportation Safety Board, Washington, D. C.
**NATIONAL TRANSPORTATION SAFETY BOARD SAFETY RECOMMENDATION**
17 Apr. 1986 2 p
(NTSB-4357/1) Avail: NTIS HC A02/MF A01

On July 16, 1984, a Hiller Aviation UH-12E helicopter, N1043L, crashed while engaged in an agricultural spraying operation near Redmond, Oregon. The helicopter was destroyed. The pilot, the sole occupant, received minor injuries. The investigation by the National Transportation Safety Board revealed that an outboard section of main rotor blade had separated in flight. Subsequent detailed examination of the fractured surfaces of main rotor blade spar in the Safety Board's metallurgical laboratory revealed that a fatigue crack had propagated through 80 percent of the spar cross section prior to separation. The fatigue crack originated at the interface between the spar lower surface leading edge and the external spar doubler. The failed blade was manufactured by the Parsons Company, a Hiller Aviation vendor, in the 1960's. The Safety Board understands that this was the fourth such blade failure since the AD was issued. All four failures reportedly occurred when the blades had accumulated about 4,000 hours, although the approved service life of the PN 2253-1101-04 blade is 6,600 hours. The inspection now being conducted at 100-hour intervals apparently is not adequate to identify fatigue crack propagation originating at the interface between the spar lower surface leading edge and the external spar doubler. The Safety Board concludes that a one-time inspection using ultrasonic or eddy current techniques should be imposed on the remaining Parsons main rotor blades with more than 3,000 hours of accumulated time, in addition to the existing AD requirement. Data from this one-time inspection program should be evaluated to determine if any further nondestructive tests are necessary or if the approved service life of the blades should be reduced. Author

**N86-29793#** Federal Aviation Administration, Washington, D.C. Emergency Evacuation Task Force.
**TASK FORCE REPORT ON EMERGENCY EVACUATION OF TRANSPORT AIRPLANES, VOLUME 1 Final Summary Report**
Jul. 1986 109 p
(DOT/FAA/VS-86/1.1) Avail: NTIS HC A06/MF A01

This is one of two volumes that report on the study of the emergency evacuation of transport airplanes that was sponsored by the Federal Aviation Administration (FAA). The study included the September 1985 Public Technical Conference and the public meetings of the three technical working groups formed during the conference as part of a task force effort. The working groups are: Design and Certification, Training and Operations, and Maintenance and Reliability. The task force program focused on the reassessment of existing Federal Aviation Regulations pertaining to emergency evacuation. Topics considered in the study include: evacuation demonstrations; emergency exits; evacuation slide certification, inspection, and maintenance; emergency equipment; crewmember training and duties; passenger safety information; air carrier operations; and others. Volume I, Summary Report, summarizes the issues considered during the study and the outcome of those issues. Volume II, Supporting Documentation, contains meeting reports, formal presentation papers, and other documents on which the summary report is based. Author

**N86-29794#** Federal Aviation Administration, Atlantic City, N.J. Technical Center.
**HALON EXTINGUISHER AGENT BEHAVIOR IN A VENTILATED SMALL AIRCRAFT Final Report, Mar. - Jul. 1984**
G. R. SLUSHER, J. WRIGHT, and J. E. DEMAREE Jun. 1986 53 p
(DOT/FAA/CT-86/5) Avail: NTIS HC A04/MF A01

Hand held fire extinguishers (Halon 1211 and Halon 1301) were evaluated in a four-passenger Cessna Model 210C aircraft. The aircraft was operated in the FAA's Technical Center airflow facility under simulated flight conditions. Extinguishers were discharged without fires to determine the dissipation rate and toxicity levels of Halon extinguishing agents. Agent concentrations dissipated rapidly. Analysis of dose calculations demonstrated that 2.5 pound Halon 1211 and 3.0 pound Halon 1301 extinguishers were safe in the four-passenger test aircraft. Dose calculations for the pilot were a maximum of 60 percent of the limit for Halon 1211, and maximum dose was 31 percent of the limit for Halon 1301. Stratification of the Halons together with cabin ventilation resulted in safe conditions for the pilot. Distribution of extinguishing agents under the instrument panel was investigated. When the extinguishers were discharged on either the pilot's or the copilot's side, four percent concentration was measured on the side opposite of the discharge of the extinguishers. Extinguisher gas stratification was determined by measuring agent levels on the cabin floor. Author

**N86-29795#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**FULL-SCALE TRANSPORT CONTROLLED IMPACT DEMONSTRATION PROGRAM PHOTOGRAPHIC/VIDEO COVERAGE Final Report, May 1983 - Dec. 1984**
J. D. GREGOIRE Apr. 1986 430 p
(Contract DTFA03-80-A-00215)
(DOT/FAA/CT-85/35; JPL-D-2534) Avail: NTIS HC A19/MF A01

The Full-Scale Transport Controlled Impact Demonstration Program was recorded on both film and video tape by the Photo-Duplication Section 642 of the Jet Propulsion Laboratory, California Institute of Technology. Photographic coverage was requested by the Federal Aviation Administration (FAA) on the antimisting kerosene (AMK) fuel and crashworthiness experiments. Instrumentation and documentation cinematography and videography produced a catalog of images that recorded completely the pre-/post-elements of the event.
Author

**N86-29796#** Federal Aviation Administration, Washington, D.C. Program Engineering and Maintenance Service.
**INVESTIGATION OF HAZARDS OF HELICOPTER OPERATIONS AND ROOT CAUSES OF HELICOPTER ACCIDENTS Final Report, Oct. 1983 - Sep. 1985**
F. R. TAYLOR and R. J. ADAMS Jul. 1986 177 p
(Contract DTFA01-80-C-10080)
(FAA/PM-86/28) Avail: NTIS HC A09/MF A01

During 1983 and 1984, Systems Control Technology, Inc. conducted a country-wide survey of civil helicopter pilot organizations involved in a wide range of helicopter operations for the purpose of determining the hazards of the latter and the root causes of the high rate of helicopter accidents. The survey was conducted through personal interviews, meetings, and questionnaires. The questionnaire included census data, profiles of the pilot work environment and procedures,and their own perspectives on the hazards of helicopter operations and causes of helicopter accidents. These data were compared with historical National Transportation Safety Board accident reports and accident briefs to determine more specifically the causes of helicopter accidents. The results of the analysis include a list of hazards and probable causes of accidents, as well as technological, training and standardization remedies.
Author

**N86-29797#** Federal Aviation Administration, Washington, D.C. Associate Administrator for Aviation Standards.
**TASK FORCE REPORT ON EMERGENCY EVACUATION OF TRANSPORT AIRPLANES. VOLUME 2: SUPPORTING DOCUMENTATION Final Report**
Jul. 1986 429 p
(FAA/VS-86/1,2) Avail: NTIS HC A19/MF A01

This is one of two volumes that report on the study of the emergency evacuation of transport airplanes that was sponsored by the Federal Aviation Administration (FAA). The study included the September 1985 Public Technical Conference and the public meetings of the three technical working groups formed during the conference as part of a task force effort. The working groups are: Design and Certification, Training and Operations, and Maintenance and Reliability. The task force program focused on the reassessment of existing Federal Aviation Regulations pertaining to emergency evacuation. Topics considered in the study include: evacuation demonstrations; emergency exits; evacuation slide certification, inspection and maintenance; emergency equipment, crewmember training and duties; passenger safety information; air carrier operations, and others, Volume I, Summary Report, summarizes the issues considered during the study and the outcome of those issues. Volume II, Supporting Documentation, contains meeting reports and other documents on which the summary report is based.
Author

**N86-29798#** Scientific Systems, Inc., Cambridge, Mass.
**VECTORED THRUST DIGITAL FLIGHT CONTROL FOR CREW ESCAPE, VOLUME 1 Final Report, 1 Jun. 1982 - 28 Feb. 1985**
J. V. CARROLL and R. F. GENDRON Dec. 1985 215 p
(Contract F33615-C-82-3402)
(AD-A166580; AFWAL-TR-85-3116-VOL-1) Avail: NTIS HC A10/MF A01 CSCL 01D

Work of Meyer and Cicolani was adapted for application to open seat escape systems in current Air Force fighter aircraft. The control system design is a fully self-contained system whose major on-seat components are: acceleration, rate, attitude and altitude sensors, real-time control logic imbedded on a microprocessor chip, rocket thrusters with thrust vectoring and throttling capability, and various avionics and support subsystem hardware items (e.g., power supply). The control concept is based on a comparison of measured translational and rotational accelerations with desired values; the propulsion system is then configured to provide adequate energy to follow the desired trajectory and simultaneously eliminate acceleration errors. The concept uses nonlinear models and incorporates state and control constraints. This volume contains the detailed documentation of specification development, control logic design, hardware identification, and trade study efforts. Volume II (Ad-A166 596) contains a description of the prototype design, real time breadboard simulation, and the results and analysis of the verification task. Volume III contains the supporting appendices for volumes I and II. Volume IV details the results of the real time hybrid computer simulation effort.
GRA

**N86-29799#** Scientific Systems, Inc., Cambridge, Mass.
**VECTORED THRUST DIGITAL FLIGHT CONTROL FOR CREW ESCAPE, VOLUME 2 Final Report, 1 Jun. 1982 - 28 Feb. 1985**
J. V. CARROLL and R. F. GENDRON Dec. 1985 208 p
(Contract F33615-82-C-3402)
(AD-A166596; AFWAL-TR-85-3116-VOL-2) Avail: NTIS HC A10/MF A01 CSCL 01D

Work of Meyer and Cicolani was adapted for application to open seat escape systems in current Air Force fighter aircraft. The control system design is a fully self-contained system whose major on-seat components are: acceleration, rate, attitude and altitude sensors, real-time control logic imbedded on a microprocessor chip, rocket thrusters with thrust vectoring and throttling capability, and various avionics and support subsystem hardware items (e.g., power supply). The control concept is based on a comparison of measured translational and rotational accelerations with desired values; the propulsion system is then configured to provide adequate energy to follow the desired trajectory and simultaneously eliminate acceleration errors. The concept uses nonlinear models and incorporates state and control constraints. Volume I (AD-A166580) contains the detailed documentation of specification development, control logic design, hardware identification, and trade study efforts. Volume II contains a description of the prototype design, real time breadboard simulation, and the results and an alysis of the verification task.
GRA

**N86-30019#** Boeing Co., Seattle, Wash.
**CURRENT DESIGN PROCEDURES FOR MINIMIZING POST CRASH FIRE HAZARDS**
H. SKAVDAHL *In* FAA Proceedings of Fuel Safety Workshop p 261-276 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

In designing jet aircraft fuel systems, experience has resulted in current attention to the following considerations for fire safety: (1) elimination of ignition sources; (2) where (1) is not possible, minimizing oxygen supply, ventilating the fuel sufficiently to prevent combustible mixtures, or eliminating the fuel source with valves or drains; (3) shrouding of fuel lines in pressurized compartments; (4) impact-resistant location of fuel tanks; (5) safety features for pressure fueling; (6) strut breakaway design; and (7) fire walls, air cooling, and careful location of fuel system components to further minimize fire hazards. Airplane fuel systems are discussed in general, and criteria which must be satisfied in the design of a new component or subsystem are described. J.P.B.

**N86-30020#** Aviation Fuel Safety Co., Chelmsford, Mass.
**AMINE-CO2 ADDUCTS AS AVIATION FUEL GELLING AGENTS**
W. W. BANNISTER *In* FAA Proceedings of Fuel Safety Workshop p 279-298 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

On addition of small amounts of cyclododecylamine (CDDN) to jet fuels, with subsequent addition of CO2, a zwitterionic carbamate forms to set up a gelling matrix within the fuel. This system is proposed for application in controlled crash landings in which the crew would have one or two second to undertake fire-prevention measures. There is also a possibility for use in very low non-gelling concentrations which may still provide antimisting kerosene (AMK) characteristics, in which case there would be no weight penalties and no reaction time would be required. Use with other additives may provide synergistic effects. Cost estimates, payload requirements, heat of combustion and NOx emission data are included. Author

**N86-30022#** Akron Univ., Ohio.
**JET FUEL VISCOSITY AT LOW TEMPERATURES WITH NOTES ON N-ALKALINE CRYSTALS Final Report**
D. SCHRUBEN *In* FAA Proceedings of Fuel Safety Workshop p 317-356 31 Dec. 1985
(Contract NAG3-488)
(NASA-CR-174911; NAS 1.26:174911) Avail: NTIS HC A17/MF A01 CSCL 21D

Apparatus and procedures were developed to collect jet fuel viscosity versus temperature data for temperatures down to about -60 deg C in a manner compatible with prior jet fuel data bases generated with the Brookfield viscometer. Viscosity data showed good reproducibility even at temperatures a few degrees into the two-phase region. The viscosity-temperature relationship could be correlated by two linear segments when plotted as a standard log-log type representation. The breakpoint between the high and low temperature line segments is the filter flow temperature, a fuel characteristic approximated by the freezing point. A generalized correlation appears sufficiently accurate for many design or performance calculations. In the low temperature two-phase region, wax precipitation is significant. Qualitative literature was quantitatively analyzed along with data in this study to plot crystal size versus composition for the fuel model C sub 20-C sub 24 n-alkane system in solvent. This suggested that wax mixtures tend towards smaller crystal sizes than pure wax species. Complex mixtures in jet fuels lead to two-phase states, at least in some instances, that have small enough crystals to be treated as a continuum. Author

**N86-30702#** Simula, Inc., Tempe, Ariz.
**SEAT EXPERIMENT RESULTS OF FULL-SCALE TRANSPORT AIRCRAFT CONTROLLED IMPACT DEMONSTRATION Final Report, Jan. - Jul. 1985**
M. R. CANNON and R. E. ZIMMERMANN (RMS Technologies, Inc., Trevose, Pa.) Jul. 1986 248 p
(Contract DTFA03-81-C-00040)
(DOT/FAA/CT-85/25; TR-85413) Avail: NTIS HC A11/MF A01

The results of the Federal Aviation Administration (FAA) seat experiments tested in the joint FAA/NASA Controlled Impact Demonstration (CID) are described. Twenty-three seats were placed on the test aircraft. Thirteen seats were modifications of existing transport seats which were designed structurally to improve their crashworthiness. The remaining experiments were unmodified standard seats which included seven light and heavy-weight forward-facing seats, two aft-facing seats, and one flight attendant seat. Three additional seat experiments were placed onboard the test aircraft: two by NASA, and one by a private contractor. Onboard instrumentation was placed at specific locations to obtain data pertaining to airframe structural loads and seat/occupant response. Accelerometers were attached to the airframe and floor structure, the seat experiments, and the anthropomorphic dummies occupying the seats. The data base resulting from the test was intended for validating crash prediction models and occupant/seat dynamic simulation models. Author

**N86-30703#** National Transportation Safety Board, Washington, D. C.
**AIRCRAFT ACCIDENT REPORT: PROVINCETOWN, BOSTON AIRLINES FLIGHT 1039, EMBRAER BANDEIRANTE, EMB-110P1, N96PB, JACKSONVILLE, FLORIDA, DECEMBER 6, 1984**
24 Jun. 1986 100 p
(PB86-910405; NTSB/AAR-86/04) Avail: NTIS HC A05/MF A01

Provincetown-Boston Airlines Flight 1039, an Embraer Bandeirante, was cleared from the Jacksonville International Airport, Jacksonville, Florida, to Tampa, Florida at 1805 eastern standard time on December 6, 1985, in visual flight conditions. There were 11 passengers and 2 crewmembers aboard the scheduled domestic passenger flight operating under 14 CFR 135. At 1812, flight 1039 was cleared for takeoff, and, at 1813, while over the departure end of the runway and climbing, the crew acknowledged a frequency change. Thirty seconds later, about 1814, the airplane was seen in a steep descent near the extended centerline of the runway. Flight 1039 struck the ground 7,800 feet beyond the departure end of runway 31 and 85 feet to the northeast (right) of the extended runway centerline in an inverted nose down attitude, after which it caught fire and burned. The airplane was demolished, and all 13 persons aboard were killed. Before ground impact, the horizontal stabilizer, including bulkhead No. 36, had separated from the fuselage. Both elevators and elevator tips, the tail cone assembly, and the aft portion of the ventral fin also had separated in flight. Author

**N86-30704#** Calspan Field Services, Inc., Arnold AFS, Tenn.
**AIRCRAFT TRANSPARENCY TESTING: ARTIFICIAL BIRDS Final Report, 1 Jul. 1984 - 1 May 1985**
C. J. WELSH and V. CENTONZE Apr. 1986 18 p Prepared in cooperation with AEDC
(AD-A166832; AEDC-TR-86-2) Avail: NTIS HC A02/MF A01 CSCL 14B

An analysis was made concerning the use of artificial birds in bird impact testing of aircraft transparencies. Results of this analysis, including impact measurements at a nominal velocity of 500 fps, indicated that the use of artificial birds for impact testing at these conditions is impractical. This follows from the importance and difficulty of simulating the shear strength characteristics of real birds in transparency impacts. GRA

**N86-30705#** Weather Corp., Weston, Mass.
**DEVELOPMENT OF AIRBORNE ELECTRIC FIELD AND LIGHTNING DETECTION INSTRUMENTATION FOR AVIATION SAFETY Final Report**
R. MARKSON 20 Apr. 1986 30 p
(Contract N00014-85-C-0707)
(AD-A167342) Avail: NTIS HC A03/MF A01 CSCL 01D

The objectives of Phase I were to investigate the use of simple corona current instrumentation on aircraft to measure thunderstorm electric fields and to conduct a feasibility study of a single station aircraft lightning interferometer to detect the occurrence and position of lightning. Both of these techniques have the common purpose of providing warning to aircraft crews when they are approaching potentially hazardous clouds and thunderstorms. The electric field measurement has the advantage of detecting electrified clouds which may not be producing lightning flashes but are nevertheless dangerous because an aircraft can trigger lightning; however this is a relatively short range system (on the order of 10 to 20 miles). The interferometer, which responds to RF pulses from lightning, has the advantage of long range detection (more than 100 miles) and can map the the position of lightning flashes in a manner similar to the way radar maps areas of rain. Thus the systems complement each other. GRA

**N86-30706#** Koninklijk Inst. voor de Marine, Den Helder (Netherlands).

**THE BLACK BOX. SILENCE IS SILVER, SPEECH IS GOLDEN [DE ZWARTE DOOS. ZWIJGEN IS ZILVER, SPREKEN IS GOUD]**

A. W. POL Jul. 1984 151 p Partly in DUTCH and ENGLISH
(ESA-86-97394) Avail: NTIS HC A08/MF A01

Requirements, design and development, and feasibility aspects of Flight Data Recorders (FDR) and Cockpit Voice Recorders (CVR) are treated. Examples of existing systems (e.g., the U.S. Navy Universal Locator Airborne Data Systems, and the solid-state FDR) are given. Installation of FDR/CVR combined crash recorders in Westland Lynx helicopters is discussed. Aircraft accident relevant information, necessary adaptions of the helicopter, and feasibility were investigated. As the present aircraft indicating instruments often contain information after accidents it is concluded that installation of only a CVR is a feasible solution. However, future aircraft instruments (e.g., digital computers, and displays) might necessitate FDRs also.
ESA

**N86-30707#** General Accounting Office, Washington, D. C. Resources Community and Economic Development Div.

**AVIATION WEATHER HAZARDS: FAA (FEDERAL AVIATION ADMINISTRATION) SYSTEM FOR DISSEMINATING SEVERE WEATHER WARNINGS TO PILOTS Briefing Report**

Apr. 1986 34 p
(PB86-195070; GAO/RCED-86-152BR; B-222882) Avail: NTIS HC A03/MF A01 CSCL 01B

Controllers at the nation's busiest airports sometimes do not have time to disseminate weather information to pilots. In addition, when weather information is given, it may not be given as soon as possible because controllers are too busy performing their primary duty of separating aircraft. FAA's procedure for communicating weather warnings by having controllers read them over their radio frequencies is too slow to avoid potential hazards, and some pilots may not receive any warning because of radio frequency changes. On-airport weather detection systems (LLWAS and ASR) do not provide controllers adequate detection or information about potentially hazardous weather because the radar cannot detect storm intensities, and the wind shear system cannot reliably detect the most dangerous form of wind shear, microbursts.
GRA

**N86-30708#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**INTERACTION BETWEEN EMP (ELECTROMAGNETIC PULSE), LIGHTNING AND STATIC ELECTRICITY WITH AIRCRAFT AND MISSILE AVIONICS SYSTEMS**

1986 144 p Presented at a Lecture Series, Ankara, Turkey, 29-30 May 1986, Oberpfaffenhofen, West Germany, 2-3 Jun. 1986, and The Hague, The Netherlands, 5-6 Jun. 1986; sponsored by Avionics Panel and the Consultant and Exchange Programme of AGARD
(AGARD-LS-144; ISBN92-835-1528-5) Avail: NTIS HC A07/MF A01

Interactions between transient electromagnetic waves with aircraft and missile avionics systems are described. Transient electromagnetic waves include electromagnetic pulses (EMP) from nuclear explosions, lightning, and static electricity. Interactions are introduced by coupling of EMP and lightning induced currents and voltages with avionics components. Shielding against these interactions is discussed with respect to induced currents and voltages from EMP and lightning, and induced voltages from static charging effects. Several examples of interactions, coupling, shielding, and measurement techniques are presented. This Lecture Series, sponsored by the Avionics Panel of AGARD, has been implemented by the Consultant and Exchange Program of AGARD.
Author

**N86-30709#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**CRASHWORTHINESS OF AIRFRAMES**

1986 34 p Presented at the 61st Meeting of the Structures and Materials Panel of AGARD in Oberammergau, West Germany, 8-13 Sep. 1985
(AGARD-R-737; ISBN92-835-1525-0) Avail: NTIS HC A03/MF A01

At its 61st Meeting the AGARD Structures and Materials Panel heard three papers as a preliminary to setting up a Sub-Committee on this topic; this publication contains these papers. They survey a range of theoretical and experimental aspects of crashworthiness relating to metallic structures. For structures made of these materials theoretical methods are becoming useful design tools, but much further development is required before composite structures can be satisfactorily handled. There is a very great need for a data base of reliable experimental information (including accident data bases) on both metallic and composite structures.
Author

## 04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A86-43484#**

**AN INERTIAL NAVIGATION SYSTEM WITH SINGLE-AXIS STABILIZATION**

S. REN and Z. LI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 578-584. In Chinese, with abstract in English.

The principles, error model and simulation results of an inertial navigation system with single-axis stabilization are addressed. The error propagation characteristics are obtained by means of covariance analysis based on the developed error model. A series iteration technique is adopted for computation. An assumed trajectory of a short range missile is used for simulating the error covariance propagation. The principle of operation of the present system is simpler than that of a pure strapdown system, and lessens the requirements of the gyro dynamic range. As a result, it is possible to utilize a cheap gyro instead of an expensive one in the execution of the same navigation and guidance missions.
Author

**A86-43708**

**APPLICATIONS OF SATELLITE COMMUNICATIONS TECHNOLOGIES TO INTERNATIONAL CIVIL AVIATION**

D. W. FREER (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) IN: SPACECOM '85; Space and Radiocommunications Symposium, 5th, Paris and Le Bourget, France, June 5-7, 1985, Speakers' Papers . Geneva, Switzerland, International Telecommunication Union, 1985, p. 75-82.

ICAO's considerations of satellite technologies for civil aviation from 1964-1985 are reviewed. The recommendations of the Application of Space Technology Relating to Aviation panel (1969) and the Aeronautical Satellite Service (1972) for the use of satellite-communication systems in aircraft are discussed. The development of a new international civil air infrastructure by the Future Air Navigation Systems (FANS) committee is examined. The disadvantages of satellite-communications and navigation systems, which include line-of-sight propagation constraints, limited flight routing flexibility, and the absence of air-ground data interchange capability, are studied. The infrastructure proposed by the FANS committee includes a satellite-based communications system with digital data and voice transmissions, nonsatellite ground-based communication capability in airport areas, global satellite navigation service, coverage from the earth surface to the 21,336 m range, and the integration of satellite-based communications, navigation, and serveillance systems. Policy issues affecting the implementation of the proposal are analyzed. I.F.

**A86-43862**

### A COMPUTER MODEL TO EVALUATE AIRBORNE RECEIVER PERFORMANCE IN INTERFERENCE ENVIRONMENTS

D. P. KOESTER, L. E. SMITH, R. R. STEVENS, JR., and C. E. COOK (MITRE Corp., Bedford, MA) IEEE Transactions on Communications (ISSN 0090-6778), vol. COM-34, May 1986, p. 462-474. refs
(Contract F19628-84-C-0001)

A computer model is described to evaluate airborne radio performance in a mixed environment of friendly and hostile emitters. A new performance criterion, the communications operability volume, is introduced. This criterion permits operational, scenario-based comparisons of various radio designs over a range of interference environments. Communications operability volumes can be calculated for different waveforms, receiver antenna patterns (including adaptive arrays), and detection thresholds. An empirical propagation algorithm is used to calculate path losses and/or maximum communications range. The computer model provides several types of graphic outputs that are used to compare antijam or electromagnetic compatibility performance for different radio designs at various locations relative to the sources of interference in a scenario. Author

**A86-44279**

### VLF RADIO NAVIGATION SYSTEMS [RADIONAVIGATSIONNYE SISTEMY SVERKHDLINNOVOLNOVOGO DIAPAZONA]

S. B. BOLOSHIN, G. A. SEMENOV, A. S. GUZMAN, G. V. GOLOVUSHKIN, and P. V. OLIANIUK Moscow, Izdatel'stvo Radio i Sviaz', 1985, 264 p. In Russian. refs

The book presents the fundamentals of the theory, operation, and implementation of VLF navigation systems commonly used for the long-range navigation of aircraft and ships. Topics discussed include the effect of propagation conditions on the operation of VLF navigation systems, methods of coordinate estimation under conditions on incomplete information on the correction model parameters, and system characteristic predictions. The discussion also covers methods of resolving the ambiguity of phase measurements, ground transmitting stations, and combining VLF navigation systems with other means of navigation. V.L.

**A86-44399**

### A GRAPHIC TERMINAL FOR AIR TRAFFIC CONTROL OF CANADIAN MILITARY AIRPORTS [LA REALISATION D'UN TERMINAL GRAPHIQUE POUR LE CONTROLE DU TRAFIC AERIEN D'AEROPORTS MILITAIRES CANADIENS]

C. Y. LAPORTE and J. L. HOULE (Montreal, Universite, Montreal, Canada) Control and Computers (ISSN 0315-8934), vol. 14, no. 2, 1986, p. 38-43. In French. refs

As part of the Terminal Aids Replacement Program, a terminal for the real-time display of up to 60 targets within a 32 nautical mile radius, with a lag of no more than 22.5 degrees with respect to the radar antenna position, was developed. Specifications were for compatibility with NOVA 3 minicomputer transmission rates, graphic translator and CRT display, 0.5 s command reaction time, and the ability to distinguish targets from other objects. Software and different processor architectures are described, and cost and reliability are considered to evaluate the advantages and disadvantages of monoprocessor versus multiprocessor structures. R.R.

**A86-46140**

### DME/P - A NECESSARY MLS COMPONENT FOR THE FUTURE

G. K. ROMREL (E-Systems, Inc., Montek Div., Salt Lake City, UT) ICAO Bulletin, vol. 41, March 1986, p. 18-21.

The design and capabilities of the precision distance measuring equipment (DME/P) of the microwave landing system (MLS) are analyzed. The DME/P is a landing aid used to guide an aircraft throughout the coverage volume of the MLS to a safe landing. The DME/P operates with a fast-rise-time pulse and coverage in the 2.4-6,100 m altitude range is provided by initial and final approach modes; the initial approach mode performs in the 13 km range and final approach mode operates from 13 km to landing. The detection accuracy possible due to the cos/cos-squared pulse-shaped signal and the Delay-Attenuation-Compare detection of the DME/P is discussed. The use of dynamic automatic delay correction circuits to eliminate potential false detection is examined. The transponder integrity design and the installation of the DME/P into aircraft are described. I.F.

**A86-46142**

### ILS GOAL - AUTOMATIC LANDINGS, SAFETY

P. LAUX (Thomson-CSF, Division Systemes Defense et Controle, Bagneux, France) ICAO Bulletin, vol. 41, March 1986, p. 27-29.

The design and functions of the instrument landing system (ILS) 381 T are described. The ILS allows for interaction between the pilot, aircraft, and the ground controller. The reliability and stability provided by the transmission chain of th IRS (VHF or UHF signal generator, amplifier and phase feedback loop of the signal, and a linear wideband amplifier) are analyzed. The use of a two-frequency array with 13-radiating elements, a 25-element, wide-aperture array, and a Thomson-CSF 'M' array to reduce the interference from reflecting objects is discussed. The monitor channels and transfer logic employed by the ILS 381 T are examined. The capabilities of the remote maintenance monitoring of the IRS 381 are considered. I.F.

**A86-46146**

### THE PROTECTED VOLUME OF AIRSPACE GENERATED BY AN AIRBORNE COLLISION AVOIDANCE SYSTEM

R. L. FORD (Royal Signals and Radar Establishment, Malvern, England) Journal of Navigation (ISSN 0020-3009), vol. 39, May 1986, p. 139-158. Research supported by the Civil Aviation Authority. refs

The features of the Traffic Alert and Collision Avoidance System (TCAS) II are described, and the operational principles of the system are explained. The shape, size, and orientation of the protected volume of the airspace are derived, showing how the threat detection logic used by TCAS II generates a volume of protected airspace enclosing own aircraft. It is also shown how the essential features of the protected volume may be used to calculate alarm rates for some simple traffic patterns. The TCAS III version, still under development, is intended to provide both horizontal and vertical escape maneuvers. I.S.

**A86-46457#**

### GRAVITY-INDUCED ERRORS IN AIRBORNE INERTIAL NAVIGATION

D. W. HARRIMAN and J. C. HARRISON (Geodynamics Corp., Santa Barbara, CA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 285-295) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 419-426. Previously cited in issue 21, p. 2991, Accession no. A84-43433. refs

**N86-29800*#** University of Southern Colorado, Pueblo. School of Applied Science and Engineering Technolo

### TECHNOLOGY RESEARCH FOR STRAPDOWN INERTIAL EXPERIMENT AND DIGITAL FLIGHT CONTROL AND GUIDANCE Final Technical Report, 1 Oct. 1979 - 31 Dec. 1984

R. A. CARESTIA and D. E. COTTRELL 1985 113 p
(Contract NCC2-41)
(NASA-CR-176907; NAS 1.26:176907) Avail: NTIS HC A06/MF A01 CSCL 17G

A helicopter flight-test program to evaluate the performance of Honeywell's Tetrad - a strapdown, laser gyro, inertial navitation system is discussed. The results of 34 flights showed a mean final navigational velocity error of 5.06 knots, with a standard deviation of 3.84 knots; a corresponding mean final position error of 2.66 n.mi., with a standard deviation of 1.48 n.m.; and a modeled mean-position-error growth rate for the 34 tests of 1.96 knots, with a standard deviation of 1.09 knots. Tetrad's four-ring laser gyros provided reliable and accurate angular rate sensing during the test program and on sensor failures were detected during the evaluation. Criteria suitable for investigating cockpit systems in rotorcraft were developed. This criteria led to the development of two basic simulators. The first was a standard simulator which could be used to obtain baseline information for studying pilot workload and interactions. The second was an advanced simulator which integrated the RODAAS developed by Honeywell into this simulator. The second area also included surveying the aerospace industry to determine the level of use and impact of microcomputers and related components on avionics systems. M.G.

**N86-29801#** Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.
**INVESTIGATIONS FOR IMPROVING OPERATIONAL RELIABILITY AND MAINTAINABILITY OF INSTRUMENT LANDING SYSTEM COMPONENTS. VOLUME 1: TEXT AND APPENDICES Final Report, Feb. 1983 - Feb. 1986**
R. H. MCFARLAND, W. D. PHIPPS, L. D. BRADY, J. DENNIS, and J. D. LONGWORTH Feb. 1986 272 p
(Contract DTFA01-83-C-20025)
(DOT/FAA/PM-86/7,1-VOL-1; OU/AEC/EER-79-1-VOL-1) Avail: NTIS HC A12/MF A01

An investigation of anomalous performance of the glide slope at Lambert-St. Louis is reported. An analysis of the Instrument Landing System (ILS) Reference Datum Heights (RDH) is reported, as well as the results of an investigation of glide slope critical areas. The feasibility of developing ground bases checking techniques for validating the Sideband Reference (SBR) glide slope is presented as well as an assessment of the current standards and tolerances used to qualify glide slope structure. In addition, a proposed methodology for mathematical model validation is discussed. Author

**N86-29802#** Federal Aviation Administration, Washington, D.C.
**ENGINEERING PERFORMANCE EVALUATION OF SMALL COMMUNITY AIRPORT MICROWAVE LANDING SYSTEM (TI-MODEL) AT PHILADELPHIA INTERNATIONAL AIRPORT RUNWAY 17 Final Report**
G. D. ADAMS and C. E. RICHARDSON Aug. 1986 68 p
(Contract DTFA01-82-Y-10521)
(FAA/PM-86/24) Avail: NTIS HC A04/MF A01

The Microwave Landing System (MLS) program is designed to meet both civil and military operational needs. It will eventually replace the Instrument Landing System (ILS). After a system/equipment development phase, the Federal Aviation Administration in 1979 began a Service Test And Evaluation Program (STEP) to obtain experience for developing criteria for siting, installation and preliminary operational procedures. Feasibility demo ground equipment from the development phase was used and user aircraft were equipped with MLS receivers. This report contains engineering evaluation of the FAA Technical Center flight test data taken on the Texas Instruments' manufactured Small Community MLS, as installed for STEP at Philadelphia International Airport Runway 17. The equipment performance was found to generally meet the FAA-STD-022b Path Following Error and Control Motion Noise requirement, but not the linearity requirement. Apparent aircraft propeller induced noise effects were identified. Author

**N86-29804#** Mitre Corp., McLean, Va.
**THE CONCEPT OF ALMOST-PARALLEL IFR (INSTRUMENT FLIGHT RULES) APPROACHES TO PARALLEL RUNWAYS**
A. C. SILVA Mar. 1986 52 p
(Contract DTFA01-84-C-00001)
(AD-A166485; MTR-86W11; FAA-DL5-86-1) Avail: NTIS HC A04/MF A01 CSCL 01B

Under today's rules independent parallel approaches are restricted to runways separated by at least 4300 feet. Currently the FAA is investigating a proposal to achieve reductions down to 3000 feet with the use of an improved surveillance system (1 milliradian accuracy/1 second update). This paper proposes new procedures to achieve such reduction, using existing radars, by executing almost-parallel MLS or ILS approaches. Almost-parallel approaches include curved paths where very shallow rates of turn are required and offset straight paths where the angle of offset with respect to the extended runway centerline is less than 3 degrees. Some issues of concern that arise, such as blunder resolution and pilot's loss of sight of other approach course during curved approaches, are discussed in this paper. Alternatives for an early implementation and site-specific sample applications are presented. The objective of this paper is to present in a concise manner this preliminary concept that has already generated some interest as a solution to reduced parallel operations. As with any new concept, analysis by all concerned parties have to be performed followed by simulations and/or demonstrations before the concept can be considered implementable. Author (GRA)

**N86-29805#** Air Command and Staff Coll., Maxwell AFB, Ala.
**WILL THE USAF NEED GROUND-BASED AIR TRAFFIC CONTROL RADAR IN THE YEAR 2000?**
G. L. VARN Apr. 1986 49 p
(AD-A166504; AD-E750871; ACSC-86-2585) Avail: NTIS HC A03/MF A01 CSCL 17G

Advanced technology in military aviation is developing rapidly. The Global Positioning System (GPS) and Microwave Landing System (MLS) will give the pilot precision navigation capability when fully deployed in the 1990s. The Joint Tactical Information Distribution System (JTIDS) will give the pilot the capability to display enemy and friendly aircraft in his area in his cockpit. At the same time, our mobile air traffic control (ATC) radars are aging and need to be replaced. But, with the new technology in the cockpit, it may be more feasible to eliminate ground-based ATC radar and let the pilot do his own ATC from the cockpit. This study examines the feasibility of a cockpit-based ATC system by looking at the requirement for military ATC, specific capabilities that new technologies give the pilot, and human considerations in a cockpit-based ATC system. The study concludes that a cockpit-based ATC system is not feasible and that there will be a need for ground-based ATC radar, at least through the year 2000. Author (GRA)

**N86-29806#** Lear Siegler, Inc., Grand Rapids, Mich. Inst. Div.
**OPERATING AND SUPPORT HAZARD ANALYSIS FOR THE SELF-CONTAINED NAVIGATION SYSTEM LSI MODEL 6216A, B AND C GROUP A**
J. T. REEVES 13 Mar. 1986 20 p
(Contract F09603-85-C-1224)
(AD-A166815; GRR-6216-014) Avail: NTIS HC A02/MF A01 CSCL 17G

This document constitutes the Operating and Support Hazard Analysis (O&SHA) for the C-130 Self-Contained Navigation System (SCNS) installation. It provides a hazard assessment of use and maintenance of the SCNS installation. The purpose of an O&SHA is to identify and control hazards to personnel and to the system, or related to production, installation, maintenance, test, operation, etc. This O&SHA is limited to installation and checkout of the A-kits and system and to the safety of personnel working in or around the equipment, including ground and flight crews. The scope of this analysis for Data Item 0103 is limited to the SCNS installation task 'A-kit' components (viz. wiring harness, brackets, racks, control panels, relay boxes, circuit breakers), B-kit components (viz. ICDUs, BICU, DVS, INU), and the physical interfaces with existing equipment (viz. CACD or Sensors, Radar, Air Data Sensors). These items will be analyzed in respect to safe installation, safe hardware, and safe usage (viz. installation, removal, in-place test, and handling). GRA

**N86-29807#** Lear Siegler, Inc., Grand Rapids, Mich. Inst. Div.
**SUBSYSTEM HAZARD ANALYSIS FOR THE LSI MODELS 6216A, B AND C SELF-CONTAINED NAVIGATION SYSGEM GROUP A**
J. T. REEVES 13 Mar. 1986 19 p
(Contract F09603-85-C-1224)
(AD-A166816; GRR-6216-013) Avail: NTIS HC A02/MF A01
CSCL 09E

This document constitutes the Subsystem Hazard Analysis (SSHA) for the C-130 Self-Contained Navigation System (SCNS) installation. It provides a safety assessment of the SCNS installation. The purpose of an SSH is to evaluate the parts making up a system for items that could adversely affect the system safety through component failure, performance degradation, functional failure and inadvertent operation. The scope of this analysis for Data Item 0103 is limited to the SCNS installation task A kit components (viz. wiring harness, brackets, racks control panels, relay boxes, circuit breakers), B-kit components (viz., ICDUs, BICU, DVS, INU), and the physical interfaces with existing equipment (viz., CADC or Sensors, Radar, Air Data Sensors). These items will be analyzed in respect to safe installation, safe hardware, and safe usage (viz. installation, removal, in-place test, and handling). GRA

**N86-30711#** Radio Technical Commission for Aeronautics, Washington, D. C.
**MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE AREA NAVIGATION EQUIPMENT USING OMEGA/VLF INPUTS**
May 1986 187 p Supersedes RTCA/DO-140
(RTCA/DO-190; RTCA/DO-140) Avail: NTIS HC A09/MF A01

Minimum operational performance standards for airborne area navigation equipment (2D and 3D) operated in the National Airspace System (NAS) using Omega/Very Low Frequency (VLF) signals are presented. Incorporated within these standards are equipment characteristics that should be useful to users, designers, manufacturers, and installers of the equipment. The performance functions and features are defined for a 2D system which performs both lateral and vertical guidance. Equipment may be manufactured and tested to meet 2D or 3D requirements (or both) in the in route mode. Author

**N86-30712#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.
**COMPREHENSIVE TEST AND EVALUATION OF THE DALMO VICTOR TCAS 2 INDUSTRY PROTOTYPES Final Report, Feb. 1986**
A. REHMANN Feb. 1986 245 p
(FAA/PM-862; FAA/CT-86/2) Avail: NTIS HC A11/MF A01

The test procedure and results of a five-part comprehensive evaluation of two prototype minimum Traffic Alert and Collision Avoidance System (TCAS) II units are described. The five parts include: (1) hardware and software verification, (2) cockpit display and operational procedure verification, (3) pilot and inflight observer training, (4) TCAS II demonstration to the aviation community, and (5) readiness for airworthiness certification testing. Overall, the minimum TCAS II prototype has matured into an acceptable test-bed for the 8-month inservice evaluation in a commercial airliner. System reliability has improved and pilot acceptance was generally good. It is expected that minimum TCAS II will provide a valuable service to airline pilots. Author

**N86-30714#** Computer Technology Associates, Inc., Englewood, Colo.
**OPERATIONS CONCEPT FOR THE TCCC (TOWER CONTROL COMPUTER COMPLEX) MAN-MACHINE INTERFACE Final Report**
H. L. AMMERMAN, E. S. BECKER, L. J. BERGEN, D. K. DAVIES, and E. E. INMAN 28 Mar. 1986 771 p
(Contract DTFA01-85-Y-01034)
(AD-A166899; FAA/AP-86/02) Avail: NTIS HC A99/MF A02
CSCL 17G

Operations Concept for the TCCC Man-Machine Interface analyzes the tower Air Traffic Controller's job in the Tower Control Computer Complex (TCCC) environment. It considers the operations in today's towers and the automated capabilities planned for the TCCC, to reach an understanding of the Controller's job after TCCC implementation. Three separate positions are analyzed: Local Control, Ground Control, and Clearance Delivery/Flight Data. Analysis results include composition graphs and narratives showing the logical flow through the sub-activities of the three positions; task analysis, presenting the tasks of each position; task characterizations, including information requirements, cognitive/sensory attributes, and performance criteria associated with each task; and a top-level dialogue description summarizing the interaction between controller and TCCC. Traceability between tasks and system level specification requirements is also provided. GRA

**N86-30715#** Federal Aviation Agency, Atlantic City, N.J.
**HARDWARE PERFORMANCE ANALYSIS OF THE BASIC NARROW MICROWAVE LANDING SYSTEM (MLS) AT WASHINGTON NATIONAL AIRPORT (DCA) IN THE SERVICE TEST AND EVALUATION PROGRAM (STEP) Final Technical Note, 1 Jan. 1981 - 30 Jun. 1983**
M. S. PLOTKA Sep. 1985 141 p
(AD-A166916; FAA/CT-TN85/19) Avail: NTIS HC A07/MF A01
CSCL 17G

This is the final technical note for the Hardware Performance Analysis of the Basic Narrow Microwave Landing System (MLS) at Washington National Airport (DCA) in the Service Test and Evaluation Program (STEP) for the period January 1, 1981 through June 30, 1983. The MLS configuration, limits of signal operation, system and subsystem operation, data collection and analysis are described. Equipment and environmental problem areas uncovered during the test and evaluation are discussed in the Results section of this report. Chargeable failures are identified and listed and engineering investigations are discussed. Remote Maintenance Monitoring System (RMMS) data analysis are presented. Conclusions and recommendations are listed. GRA

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-43477#**
**APPLICATION OF ROTOR INDUCED VELOCITY FIELD OF THE VORTEX THEORY TO THE STUDY OF STABILITY AND CONTROLLABILITY OF HELICOPTER WITH HINGELESS ROTOR**
Z. XIN (Air Force Research Institute, People's Republic of China) and S. WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 521-529. In Chinese, with abstract in English. refs

With the aim of developing a new rotor system, a method is presented for calculation of stability and controllability of helicopter with a hingeless rotor. The effects of nonuniformity in rotor-induced velocity distribution and blade flapping elasticity are taken into account and investigated in detail. This is the first time that the first harmonic term of rotor-induced velocity distribution derived from the generalized vortex theory of rotor is employed, and a close form of equation for the induced velocity and circulation is established. Finally, analytic formulae suitable to engineering applications are given which consider the effects of the motion parameter, control parameter, blade flapping elasticity, and so on. Also, the effect of the second flapping mode on stability and controllability of helicopter with hingeless rotor is discussed. The calculations show that only the first flapping bending mode should be taken into account in stability and controllability calculation of helicopter with hingeless rotor in the range of mu less than 0.3. Finally, a typical Bo-105 helicopter is taken as a numerical example, and it is found that the results are in good agreement with its flight-test data. Author

**A86-43487#**

### IMPROVEMENT OF SERVO SYSTEMS FOR FLIGHT SIMULATOR

D. SUN (China Precision Engineering Institute for Aircraft Industry, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 597-601. In Chinese, with abstract in English.

A great deal of experimental research was done on simulator servo systems during the development of the YMT-S1 type simulator. A modification of its design was accomplished by improving a 'double velocity' servo system, a velocity or position servo system with velocity differential feedback, and an 'integral control' servo system. The experiments have proved that these three types of servo system have tangible results in improving performances of the simulator. Their formation, working principles and results are presented. Author

**A86-43490#**

### APPLICATION OF HARMONIC ANALYSIS METHOD TO RESEARCH ON ROTOR AIRLOADS

Z. QIU (Chinese Helicopter Research and Development Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 11-18. In Chinese, with abstract in English.

Using the rotor vortex theory, the rotor airflow and the rotor induced velocity are developed into Fourier series. The flow distribution along the blade spanwise is expressed in terms of segment-by-segment linear functions and the induced velocity equations and the flow equations are derived. The engineering application of the rotor vortex theory is provided. Then the induced velocity and its harmonic components are obtained to provide a quantitative basis for the vortex model. To calculate each order harmonic components of the induced velocity a simplified method is forwarded which considers the effects of each order flow while neglecting those of a higher order. The method saves computer time and is of significant benefit. Author

**A86-43776**

### DURABILITY AND DAMAGE TOLERANCE IN AIRCRAFT DESIGN; PROCEEDINGS OF THE THIRTEENTH SYMPOSIUM, PISA, ITALY, MAY 22-24, 1985

A. SALVETTI, ED. and G. CAVALLINI, ED. (Pisa, Universita, Italy) Symposium sponsored by the International Committee on Aeronautical Fatigue; Organized by the Italian Association for Aeronautical Fatigue. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, 684 p. For individual items see A86-43777 to A86-43798.

The conference presents papers on fatigue and damage tolerance work during the aircraft design process, fatigue life prediction in the crack initiation and crack propagation stages, the significance of flight-simulation fatigue tests, fatigue life under compression-dominated spectra, fatigue cracking of aluminum under spectrum loading at various humidities, increasing fatigue and crack growth lives of short-edge-margin holes and the evaluation of materials degradation due to cyclic loading in composites. Also considered are U.S. Army requirements for damage tolerance of composite helicopter structure, the damage tolerance test program of the Fokker 100, a continuing structural integrity program for transport aircraft, a maintenance system by means of the damage tolerance principle and a rationale for the safe operation of an aircraft fleet having known cracks in its primary structure. Papers are also presented on the residual strength characterization of jet transport structures, a simple crack closure model for predicting fatigue crack growth under flight simulation loading, the effect of residual stress fields at notches on fatigue crack growth and the certification of airframes and components in metals and components. K.K.

**A86-43777**

### FATIGUE AND DAMAGE TOLERANCE WORK DURING THE AIRCRAFT DESIGN PROCESS

L. JARFALL (SAAB-Scania AB, Linkoping, Sweden) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 1-31. refs

Stress office routine procedures for the handling of fatigue life and damage tolerance work during the design process are reviewed and discussed. Four main tasks are identified: Handling of spectra, Planning of tests, Fatigue life and Crack growth predictions. Examples of procedures and experiences are taken from an actual fighter aircraft project. Author

**A86-43779**

### THE SIGNIFICANCE OF FLIGHT-SIMULATION FATIGUE TESTS

J. SCHIJVE (Delft, Technische Hogeschool, Netherlands) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 71-170. refs

Results of flight-simulation fatigue tests drawn from many literature sources are analyzed to reveal the effects of truncating high loads, omitting low-amplitude cycles, the minimum stress of ground-air-ground cycles, design stress levels, sequence of flights and loads within a flight and material thickness. Tests with gust-dominated wing load spectra and maneuver-dominated wing load spectra are considered separately, which is also done for results on crack initiation life and on crack growth. Special attention is paid to standard load histories TWIST and FALSTAFF. Recommendations are given for the planning of flight-simulation tests, especially for full-scale tests. Attention is paid to comparative flight-simulation tests and the meaning of such tests for fatigue prediction problems. Author

**A86-43785**

### U.S. ARMY REQUIREMENTS FOR DAMAGE TOLERANCE OF COMPOSITE HELICOPTER STRUCTURE

J. P. WALLER and R. S. MCLELLON (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 297-316.

Preliminary U.S. Army damage tolerance design criteria are presented with a rationale for their development. A brief description of previous Army experience in the application of composites on military helicopters is included with a discussion of relevant technology and future applications. Author

**A86-43786**

### DAMAGE TOLERANCE TEST PROGRAM OF THE FOKKER 100

A. A. JONGEBREUR, E. P. LOUWAARD, and R. V. VAN DER VELDEN (Fokker, Schiphol, Netherlands) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 317-349. refs

The Fokker 100 is an advanced new twin turbofan aircraft with a redesigned super critical wing and increased utilization of composites. The objective with regard to damage tolerance is to satisfy the latest requirements. During the decision making process of how this is accomplished in terms of analysis and supporting tests, several special aspects were considered, e.g., the availability of test- and operational experience of the F28 'Fellowship', with which the Fokker 100 has much in common, and the time schedule of the Fokker 100 program. The test program as finally adopted, comprises full scale flight simulation testing for a large part of the aircraft. Author

**A86-43787**

**AIRBUS INDUSTRIE A310 AND A300-600 EXPERIENCE WITH PRACTICAL APPLICATIONS OF DAMAGE TOLERANCE DESIGN IN FUSELAGE PRIMARY STRUCTURE**

H.-J. SCHMIDT and C. L. HAMMOND (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 351-382. refs

A brief description of the current damage tolerance requirements for a civil aircraft primary structure is given as well as examples of application to the A310 and A300-600 fuselage structure. Comparisons between analysis and full-scale test results for selected points are presented along with resulting repercussions for future design and for the development of the required inspection programs. Finally, conclusions and recommendations are given for the future application of a damage tolerance design and for additional work required to better understand the damage tolerance behavior of complex structures. Author

**A86-43788**

**CONTINUED AIRWORTHINESS OF DAMAGE TOLERANT AIRCRAFT**

D. R. TURNER, R. BANISTER, and P. TO IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 383-393.

The CL-600 was the first aircraft to address the damage tolerance evaluation of FAR 25.571 amendment 45. Compliance was shown and FAA type approval was granted in February 1983. This paper discusses some of the certification activities which occurred after this time due to a reevaluation of the CL-600 by Transport Canada and also the introduction of the CL-601 version with a General Electric Engine. The impact on the maintenance and repair manuals is discussed. Author

**A86-43790**

**DAMAGE TOLERANCE AND DURABILITY IN THE DESIGN OF A SHORT-HAUL TURBOPROP AIRCRAFT**

A. GALASSO, A. DEL CORE (Aeritalia S.p.A., Gruppo Velivoli Trasporto, Pomigliano d'Arco, Italy), G. CAVALLINI, and A. LANCIOTTI (Pisa, Universita, Italy) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 423-472.

The fatigue design of the ATR 42 aircraft is presented from the point of view of its durability and damage tolerance. An account is given of the durability tests carried out on joint specimens and of the damage tolerance tests carried out on both standard specimens and stiffened panels. The various aspects of full-scale fatigue tests are described, and included in test objectives are the following: (1) the verification of the fatigue life objectives of the ATR 42 airframe, (2) the identification of fatigue critical areas by means of a test program that represents service loading conditions, and (3) the examination of crack propagation as well as inspection and repair methods in an effort to define inspection intervals and repair methods. It is noted that this test is presently running successfully and has reached 12,000 simulated flights. K.K.

**A86-43795**

**RESIDUAL STRENGTH CHARACTERIZATION OF JET TRANSPORT STRUCTURES**

U. G. GORANSON, C. K. GUNTHER, and W. T. HARDRATH (Boeing Commercial Airplane Co., Seattle, WA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 585-603. refs

The principles of residual strength analysis procedures developed to account for local redistribution and component failures are outlined and their applicability to damaged jet transport structures is assessed. A model which predicts maximum load and stable crack growth for stiffened panels is described. It operates on the basis of compatibility of displacements at the fastener location, considers elastic-plastic behavior for the fasteners and stingers, takes any elemental failure into account and is capable of analyzing stable crack growth in the skin panel material. A residual strength analysis procedure which takes the transition between linear elastic fracture mechanics failure and net section yield into consideration is also developed. K.K.

**A86-43930**

**THE OPTIMIZATION OF SEAPLANES - NEW CHANCES AND REQUIREMENTS REGARDING FLYING BOATS [ZUR OPTIMIERUNG VON SEEFLUGZEUGEN - NEUE CHANCEN UND ANFORDERUNGEN AN FLUGBOOTE]**

RWTH-Themen, no. 2, 1986, p. 52-56. In German.

The present situation concerning a demand for seaplanes is considered. It is found that aircraft which are designed to take off from and land on water would be very useful for a number of countries. Thus, in countries consisting of many islands, such as the Philippines and Indonesia, such aircraft could provide a very convenient means of transportation for people, freight, and mail. Other countries which could profit from a use of such aircraft are those having suitable bodies of water in their interior, taking into account Canada, Brazil, Finland, and countries which can utilize lake and river systems in Africa. The aircraft considered could also be very useful for surveillance and rescue operations, and in operations against forest fires it would be easier to take up water by landing on a body of water. The requirements which the aircraft would have to satisfy to perform their prospective functions are discussed along with suitable aircraft design features. G.R.

**A86-44001**

**X-WING ROTOR SYSTEMS TEST VEHICLE SCHEDULED FOR FLIGHT IN OCTOBER**

S. W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 16, 1986, p. 52, 57.

The X-wing configured S-72 rotor systems research aircraft is scheduled to fly in October 1986 to test the X-wing's start/stop characteristics in the 180-200 kt range. This X-wing VTOL vehicle uses two forward- and two aft-swept wings to fly, but can rotate these in the manner of a helicopter rotor for hover. Rotor blade lift control is furnished by air ingested and expelled through leading and training edge slots. In fixed-wing flight, rotor airfoil pitch control is achieved through variable fore and aft air blowing and the use of a horizontal stabilizer. O.C.

**A86-44003#**

**RAFALE WILL KEEP TRICOLOR FLYING**

P. LANGEREUX Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 26-28, 30.

An evaluation is made of the design features and prospective performance levels of France's Rafale experimental fighter aircraft, with reference to the European Fighter Aircraft technolgy demonstration work that is being simultaneously undertaken by a consortium of European manufacturers. Rafale is envisioned in two variants, for attack and air defense; both versions will have 12 external hardpoints, evenly divided between the wings and fuselage. The configuration of Rafale is of the canard-delta type, with two engines and single seat cockpit. High lift devices are employed on both the leading and trailing edges of the wings, facilitating maneuvers at currently unachievable angles of attack. The Rafale's structural mass comprises 25 percent composites. O.C.

**A86-44004#**

### NEW TECHNOLOGIES FOR A EUROPEAN FIGHTER

J. VINCENT (British Aerospace, PLC, Weybridge, England) Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 34-36.

The state-of-the-art technologies that will be integrated into the European Experimental Aircraft Program (EAP) fighter aircraft are discussed, and their prospective performance levels are assessed. EAP's configuration is of the canard-delta type, and a full authority digital fly-by-wire system is employed to maximize this inherently unstable configuration's agility with minimum pilot workload. The large wing area employed is prompted by both high turn rate and low speed/short landing run requirements. Stealth technology features are incorporated to maintain low radar signature. Extensive use is made of carbon fiber-reinforced composite structures. O.C.

**A86-44283**

### FLIGHT TESTING OF THE NAVIGATION AND FLIGHT CONTROL COMPLEXES OF AIRCRAFT AND HELICOPTERS [LETNYE ISPYTANIIA PILOTAZHNO-NAVIGATSIONNYKH KOMPLEKSOV SAMOLETOV I VERTOLETOV]

E. G. KHARIN, ED. Moscow, Izdatel'stvo Mashinostroenie, 1985, 128 p. In Russian. No individual items are abstracted in this volume.

Methods for testing and evaluating the performance characteristics of the navigation and flight control complexes of flight vehicles are presented. In particular, attention is given to the theory and methods of evaluating the accuracy of navigation and flight control, assessing the performance of the algorithms of on-board navigation systems, and identifying models of errors characteristic of the navigation and flight control equipment. The discussion also covers methods of evaluating flight safety in relation to the reliability of the navigation and flight control systems. V.L.

**A86-44386*** Rice Univ., Houston, Tex.

### OPTIMAL TAKE-OFF TRAJECTORIES IN THE PRESENCE OF WINDSHEAR

A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Atlanta, GA) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 49, April 1986, p. 1-45. refs

(Contract NAG1-516)

The present consideration of takeoff trajectory optimization in eight different fundamental problems involving wind shears assumes that the power setting is held at the maximum value, and that the aircraft is controlled with respect to angle-of-attack. While the first three problems are least-squares ones of the Bolza type, the remaining five are minimax problems of the Chebyshev type which can be converted to Bolza type by means of suitable transformations. All problems are solved on the basis of the dual sequential gradient-restoration algorithm for optimal control problems. The trajectory solutions obtained are superior to constant angle-of-attack trajectories. O.C.

**A86-44460**

### OPTIMIZING THE NOTAR DESIGN

Aerospace Engineering (ISSN 0736-2536), vol. 6, June 1986, p. 52-57.

The operating principles and design history of NOTAR, a no-tail-rotor antitorque system for single-main-rotor helicopters, are reviewed and illustrated with drawings, diagrams, and photographs. The primary components of NOTAR include a vertical fin, a tail boom, and an engine-driven variable-pitch fan (at the rear of the fuselage), circulation-control slots, and a direct jet thruster at the rear of the tail boom. Consideration is given to preliminary design concepts; the use of computer models to improve the design; wind-tunnel, flow-visualization, water-tank-LDV, whirl-stand, and flight testing; and the development of a specialized advanced-design tail fan. T.K.

**A86-44776**

### THE BOEING CREW ESCAPE TECHNOLOGIES (CREST) PROGRAM

R. F. YURCZYK (Boeing Military Airplane Co., Seattle, WA) SAFE Journal, vol. 16, no. 2, Summer 1986, p. 6-12.

Boeing completed Phase I of the CREST program and was recently awarded a contract for the next phase, IIA. The first phase consisted of requirements analysis and subsystem trade studies concluding with a System Design Review. Work included establishment of a performance baseline; development of a system specification and preliminary development specifications for the hardware and software subsystems; initial system design; and cockpit integration. Phase IIA consists of subsystem preliminary design and detail test planning concluding with a Preliminary Design Review of each configuration item. This paper describes the Boeing approach to the requirements of the CREST program with an overview of the system initial design. Author

**A86-44853*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

### NOISE CONTROL CHARACTERISTICS OF SYNCHROPHASING. I ANALYTICAL INVESTIGATION

C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1063-1068. Previously cited in issue 01, p. 4, Accession no. A85-10898. refs

(Contract NAG1-390)

**A86-44886*#** Informatics General Corp., Palo Alto, Calif.

### TRANSONIC AEROELASTIC ANALYSIS OF THE B-1 WING

G. P. GURUSWAMY (Sterling Software/Informatics, Palo Alto, CA), P. M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA), H. IDE, and G. D. MILLER (Rockwell International Corp., Los Angeles, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 547-553. refs

(AIAA PAPER 85-0690)

The flow over the B-1 wing is studied computationally, including the aeroelastic response of the wing. Computed results are compared with results from wind tunnel and flight tests for both low- and high-sweep cases, at 25.0 and 67.5 deg, respectively, for selected transonic Mach numbers. The aerodynamic and aeroelastic computations are made by using the transonic unsteady code ATRAN3S. Steady aerodynamic computations compare well with wind tunnel results for the 25.0 deg sweep case and also for small angles of attack at 67.5 deg sweep case. The aeroelastic response results show that the wing is stable at the low-sweep angle for the calculation at the Mach number at which there is a shock wave. In the higher-sweep case, for the higher angle of attack at which oscillations were observed in the flight and wind tunnel tests, the calculations do not show any shock waves. Their absence lends support to the hypothesis that the observed oscillations are due to the presence of leading-edge separation vortices and not to shock wave motion, as was previously proposed. Author

**A86-44887#**

### RAPID SIZING METHOD FOR AIRPLANES

J. ROSKAM (Kansas, University, Lawrence) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 554-560. Previously cited in issue 01, p. 9, Accession no. A86-10960.

**A86-44894#**

### THE ROLE OF STRUCTURAL AND AERODYNAMIC DAMPING ON THE AEROELASTIC BEHAVIOR OF WINGS

I. LOTTATI (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 606-608. refs

The significant influence of the unsteadiness of a wake on flutter speed is presently demonstrated for a high aspect ratio rectangular wing that is idealized in terms of a box beam. Attention is also given to the influence of structural damping on the flutter speed, as related to the aerodynamic damping modeled by the aerodynamic air forces that are incorporated in the analysis. Many useful conclusions are drawn from close examination of the concept of computing the critical velocity of the system by frequency coalescence. O.C.

**A86-44936**
**SOCIETY OF EXPERIMENTAL TEST PILOTS, SYMPOSIUM, 29TH, BEVERLY HILLS, CA, SEPTEMBER 25-28, 1985, PROCEEDINGS**
Lancaster, CA, Society of Experimental Test Pilots, 1985, 292 p. For individual items see A86-44937 to A86-44950.

The present conference on recent achievements in flight testing methodology considers F-14A engine air intake icing conditions, the XV-15 tilt-rotor aircraft flight test program history, naval aircraft weapons system integration experience in the U.S. Navy, flight test and early service performance of the B 737-300 airliner, a high technology training simulator for cost reduction, initial flight test results from the X-29 program, and data from the AV-8B's high angle-of-attack/spin test program. Also discussed are metrics for advanced fighter agility performance, F-14 departure/spin and air combat maneuvering evaluation using a NASA FCS, Tornado high speed terrain-following performance testing in mountainous terrain and bad weather, A320 airliner flight controls, flight tests of the Voyager unrefueled circumnavigation aircraft, the orbital salvage operations conducted by STS mission 51-A, and aerobatic testing of the BK-117 helicopter. O.C.

**A86-44937**
**F-14A INLET ICING**
G. FREEMAN and B. M. PICARD (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 3-23.

The problem of ice forming on F-14A engine inlet surfaces and on certain conditions being shed into the engine, with resulting FOD (foreign-object-damage) is examined. The F-14A Tomcat is more susceptible to inlet icing problems than any other operational Navy airplane. The problem ice forms in the number three ramp area and normally sheds out the bleed door on the top of the fuselage with little probability of FOD. If substantial ice exists, however, when the aircraft is arrested on landing, the ice can dislodge with severe FOD a serious possibility. The Navy has designated the F-14A icing a Category IA hazard, defined as having catastrophic potential with frequent occurrence. Wind-tunnel tests, validated by flight tests, indicated that ice on the back wall of ramp three had been shed from the leading edge of ramp three. The test aircraft and instrumentation are described along with an inlet airflow survey, icing tests, and maneuvering tests. A modified 'anti-ice' inlet was developed which will effectively reduce ice accumulation on the leading edge of ramp three and eliminate ice accumulation above ramp three, thus minimizing the potential for engine FOD. The new inlet has demonstrated stall free engine/inlet compatibility during flight maneuvering up to 35 Kft and 0.9 indicated Mach number and is satisfactory for the fighter mission. D.H.

**A86-44938*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**THE XV-15 TILT-ROTOR FLIGHT-TEST PROGRAM**
D. C. DUGAN (NASA, Ames Research Center, Moffett Field, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 24-41. refs

The XV-15 Tilt-Rotor flight research program is described; it has resulted in the full-scale development of the Navy's MV-22A Osprey which will be the world's first operational tilt rotor aircraft. Proof-of-concept flight test objectives have been completed along with military service tests and demonstrations. NASA Ames and Bell Helicopter Textron are currently engaged in advanced flight research programs. The government flight test activity is dicussed. It includes hover tests both in ground effect (IGE) and out of ground effect (OGE) for performance, downwash and noise measurements, short-field takeoff and landing (STOL) evaluations, aeroelastic stability investigations, dynamic stability tests, and three-axis sidestick-controller development and evaluation. Advanced Technology Blades will be installed and evaluated under all flight conditions. D.H.

**A86-44940**
**BOEING 737-300 FLIGHT TEST AND THE FIRST NINE MONTHS SERVICE EXPERIENCE**
J. C. MCROBERTS (Boeing Commercial Airplane Co., Seattle, WA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 51-66.

**A86-44941**
**NORTHROP'S SURROGATE TRAINER**
F. S. DOTEN (Northrop Corp., Electro-Mechanical Div., Anaheim, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 67-92.

The Surrogate Trainer, developed specifically to ensure that the new Apache attack helicopter is fielded with fully trained crews, is described. The Apache helicopter itself was developed with a full complement of weapons to include the standard mini-guns and rockets but enhanced with a chaingun and laser-guided missiles. It has a target acquisition/designation system capable of day and night operations, allowing the crew to fly nap-of-the-earth (NOE) as freely by night as by day. The particular Apache subsystem described is called the Pilot Night Vision Sensor (PNVS); it provides the pilot with the capability of flying night NOE with infrared video as the sole external visual reference. The surrogate Trainer is the name given to the TH-1S helicopter after the PNVS is installed. Topics covered include: PNVS How it works; the integrated helmet and display sight system; symbology generation; subsystem integration; design implementation; aft cokpit; front cockpit; data entry and display panel; blackout curtains; videotape recorder; fault detection and location system; power; ammunition bay pallet; subsystems integration; and flight testing. D.H.

**A86-44942*** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
**X-29 INITIAL FLIGHT TEST RESULTS**
S. D. ISHMAEL (NASA, Flight Research Center, Edwards, CA) and T. WIERZBANOWSKI (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 95-113.

It is announced that the X-29 forward-swept-wing (FSW) aircraft has been built, with flight testing under way and proceeding smoothly. The X-29 is a single-seat, single-engine supersonic aircraft that blends an optimized FSW, a close-coupled near-coplar canard, an F-5A forward fuselage module employing two side-mounted engine inlets, and a new aft fuselage. An F404-GE-400 engine with afterburner provides about 16,000 lb of thrust. The X-29 was designed to be near neutrally stable in the supersonic region to minimize drag; it becomes highly unstable transonically and subsonically, which dictates the use of a computerized fly-by-wire flight control system capable of stabilizing the aircraft. The X-29 advanced technology demonstrator began flight testing on Dec. 14, 1984; by Sept. 26, 1985, its envelope had been expanded to 0.75 Mach, 350 knots estimated airspeed, and 30,000 feet altitude. The aircraft has flown with very few problems and aerodynamic, structural, and control system results have correlated well with predictions. Areas where prediction and performance are not so well correlated are noted. D.H.

**A86-44943**

### AV-8B HIGH ANGLE OF ATTACK/SPIN PROGRAM

W. W. LOWE (McDonnell Aircraft Co., St. Louis, MO) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 114-133.

Program commitments and accomplishments are noted with regard to the AV-8B (Harrier II) high angle of attack test program. The program was originally structured to define boundaries of controllable flight, to explore departure dynamics and recovery, and to investigate spins if encountered. However, since earlier Harrier II testing had uncovered undesirable departure tendencies, an additional program commitment was made to correct this problem. Hardware changes made during the pre-program layup included: modifying the rudder actuator relief valve to give 15 percent more hinge moment to resist sideslip; reworking the aileron actuators to allow 6 degrees of servo authority (with new servo authority increased to 34 percent of total surface travel); adding an additional lateral accelerometer and roll rate gyro forward of the CG to provide feedback loop stability; and providing a lateral stick position sensor to implement a roll/yaw interconnect. Resistance to spin is extreme for the Harrier II. Even for lateral asymmetries to 7500 ft lb, aggravated with other than neutral controls to trigger a spin. If a spin is ever encountered, aerodynamic controls are powerful enough to effect recovery. Procedures are given for both inverted and upright spin recovery. D.H.

**A86-44945**

### TORNADO HIGH SPEED TERRAIN FOLLOWING TESTING IN MOUNTAINOUS TERRAIN AND BAD WEATHER

P. WEGER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 180-195.

The development and flight testing of a terrain-following system for the West German jet fighter Tornado are described. After more than 200 developmental flights, it has been possible to achieve final clearance for flying the aircraft at the lowest clearance height at 600 knots in mountainous terrain under full instrumental meteorological conditions. Equipment, the test area in the Schwarzwald of southwest Germany, crewing, aircraft system considerations, the O-G problem, flight control system considerations, the EMI problem, flight envelope, flight director use, terrain-following-system changes, system set-up, the warning system, weather, Category II landing capability, and open loop pull-up training are among the topics covered. The dynamics of flight at 600 knots over rough terrain in the hard-ride mode in frontal weather areas was described as 'breathtaking'. Advice is given for the pilot making use of the terrain following system.

D.H.

**A86-44947**

### CERTIFICATION FLIGHT TESTING OF CIVILIAN HELICOPTERS IN THE UNITED KINGDOM

P. J. G. HARPER (Civil Aviation Authority, London, England) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 211-222.

**A86-44948**

### FLIGHT TESTING THE VOYAGER - A NON-STOP, UNREFUELED, AROUND-THE-WORLD AIRCRAFT

R. G. RUTAN and J. L. YEAGER (Voyager Aircraft, Inc., Mojave, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 226-235.

Attention is given to the design features, mission requirements, performance characteristics, and flight test program accomplishments of the 'Voyager' long distance aircraft, which has been designed to circumnavigate the globe without refueling. The flight test program is divided into two phases that are respectively dedicated to verify performance predictions and to refine stability and control systems. Attention is presently given to lateral stability and control, bank-recovery deficiency at low speed, autopilot and avionics performance criteria, and aeroelastic airframe behavior. Flight test results are also presented. O.C.

**A86-44950**

### AEROBATIC TESTING OF THE BK-117 HELICOPTER

G. A. SHARON and E. TAVARES (U.S. Army, Aviation Engineering Flight Activity, Edwards AFB, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 262-283.

An evaluation is made of the results obtained in aerobatic flight tests of a BK-117 helicopter, with a view of such maneuvering capabilities' applicability to increasingly important helicopter air-to-air combat. Attention is given to the performance envelope of the BK-117 test helicopter, test conditions, and helicopter behavior in the standard aerobatic/combat maneuvers known as 'modified lazy-eight', 'hammerhead', roll, loop, 'one-half Cuban eight', 'reverse one-half Cuban eight', and 'pushover'. O.C.

**A86-45064**

### BRITISH EXPERIMENTAL AIRCRAFT PROGRAM PROVIDING INSIGHT INTO NEW TECHNOLOGY

D. A. BROWN Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 71, 73, 76.

The British Experimental Aircraft Program (EAP) technology demonstrator aircraft program is discussed. This aircraft is not a prototype, but rather serves to provide in-flight technical evaluation of a number of different emerging technologies, all of which are combined in the design. Six performance objectives for the aircraft are summarized along with seven project objectives intended to demonstrate that the aircraft can meet its performance objectives. The system has four flight control computers rather than the six used on the Jaguar, and uses software different from that for the Jaguar because of the different flight characteristics of the EAP. The drives for the aircraft control surfaces and for the instruments are described, and the functioning of the control system is summarized.

C.D.

**A86-45406*#** Cambridge Acoustical Associates, Inc., Mass.

### STRUCTUREBORNE NOISE INVESTIGATIONS OF A TWIN ENGINE AIRCRAFT

J. M. GARRELICK, J. E. COLE, III, and K. MARTINI (Cambridge Acoustical Associates, Inc., MA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs
(Contract NAS1-18020)
(AIAA PAPER 86-1905)

The interior noise of aircraft powered by advanced turbo-prop concepts is likely to have nonnegligible contributions from structureborne paths, these paths being those involving propeller loads transmitted to the structures of the lifting surfaces. As a means of examining these paths, structural measurements have been performed on a small twin-engine aircraft, and in addition analytical models of the structure have been developed. In this paper results from both portions of this study are presented.

Author

**A86-45407#**

### CABIN NOISE CHARACTERISTICS OF A SMALL PROPELLER POWERED AIRCRAFT

H. V. L. PATRICK (North Carolina State University, Raleigh) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs
(AIAA PAPER 86-1906)

A transfer function between engine vibrations and cabin noise of a Cessna 172 'Skyhawk' airplane was obtained by shaking the static engine. During flight conditions, the same parameters were measured recorded, and analyzed. Cabin noise was predicted based upon the transfer function and compared with actual cabin noise measurements obtained at 5000 ft altitude and engine rotation speed of 2400 rpm. It was concluded that engine vibrations do not appreciably contribute to cabin noise via a structure borne path at 2,400 rpm. Other conclusions obtained were that the cabin noise is dominated by propeller rotation noise at the blade-passing frequency and that wind screen vibrations contribute significantly to cabin noise at 2,400 rpm. At an engine rotational speed of 2,100 rpm the cabin noise spectrum was noticeably different than at 2,400 RPM and there was strong evidence of structure-borne noise. Author

**A86-45426*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EFFECTS OF AN INTERNAL FLOOR ON LOW FREQUENCY SOUND TRANSMISSION INTO AIRCRAFT CABINS - AN EXPERIMENTAL INVESTIGATION**

J. D. JONES and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs
(Contract NAG1-390)
(AIAA PAPER 86-1939)

A simplified cylindrical model of an aircraft fuselage is used to experimentally study the effects of an internal floor on low frequency sound transmission into aircraft cabins. A scaled-down lattice floor support and floor skin are designed based upon selected characteristics of a business aircraft. Thus, the model provides a simplified procedure for studying the effects of various structural modifications as well as other important effects. Modal decomposition of the shell response and the corresponding pressure response at various interior locations are presented. Results indicate that the main effect of the floor on interior pressure levels is due to modification of the interior acoustic mode shape and not due to the structural modification of the fuselage caused by the lattice floor support. Author

**A86-45427*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**STRUCTURAL INFLUENCE OF CABIN FLOOR ON SOUND TRANSMISSION INTO PROPELLER AIRCRAFT - ANALYTICAL INVESTIGATIONS**

C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs
(Contract NAG1-390)
(AIAA PAPER 86-1940)

The structural influence of the cabin floor on the transmission of low frequency propeller noise into aircraft interiors has been examined using a simplified analytical model. The response amplitudes and distributions of shell displacement and internal acoustic pressure are examined for various frequencies and floor configurations. In general, at lower frequencies the floor exerts little structural influence on the transmission of acoustic energy to the interior. However, as the frequency nears half the cylinder ring frequency the floor can be seen to significantly alter the internal pressure distributions and response. Author

**A86-45442*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ACTIVE CONTROL OF PROPELLER INDUCED NOISE FIELDS INSIDE A FLEXIBLE CYLINDER**

H. C. LESTER (NASA, Langley Research Center, Hampton, VA) and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 18 p. refs
(AIAA PAPER 86-1957)

An active noise control model has been evaluated for reducing aircraft interior noise. The structural noise transmission properties of an aircraft fuselage were modelled as a flexible cylinder excited by external acoustic dipoles simulating the noise produced by twin propellers. The amplitudes of an internal distribution of monopole control sources were determined such that the area-weighted mean square acoustic pressure was minimized in the propeller plane. The noise control model was evaluated at low frequencies corresponding to the blade passage frequency and first few harmonics of a typical turbo-prop aircraft. Interior noise reductions of 20 25 dB were achieved, over a substantial region of the cylindrical cross-section, with just a few monopole control sources. The most favorable interior noise reductions were achieved when the active noise control model was used in combination with propeller source phasing. Author

**A86-45449*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**AN EXPERIMENTAL INVESTIGATION OF REDUCING ADVANCED TURBOPROP CABIN NOISE BY WING SHIELDING**

J. H. DITTMAR (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 18 p. Previously announced in STAR as N86-25218. refs
(AIAA PAPER 86-1966)

An experimental investigation was undertaken to determine if wing shielding could reduce the noise impacting the fuselage of an advanced turboprop airplane. Four wings were tested behind two eight-bladed propeller models. Significant shielding of the propeller noise was observed and a particular wing-propeller geometry was identified to provide the most shielding. Specifically, an up-inboard rotation would be needed for a low-wing airplane and a down-inboard rotation for a high-wing airplane. As the axial Mach number was increased, the position where the shielding starts moved farther downstream. This shift in the start of shielding was roughly a straight line with respect to Mach number between M = 0.7 and M = 0.8. At M = 0.85 the start of shielding does not shift any farther downstream. A simple barrier noise-reduction model gave the same trends with transducer positions as did the data, and, if corrected for Mach number shift, the model might be used to provide estimates of the wing shielding. Besides providing a barrier to the noise reaching the shielded area, the wing also reflects some of the noise back onto the unshielded area. This can make the noise difference between the unshielded and shielded areas of the fuselage larger than would be expected by simple wind shielding. Author

**A86-45450*#** Kentron International, Inc., Hampton, Va.

**WING LOADS INDUCED BY A PROPELLER WAKE**

D. S. WEIR (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p.
(Contract NAS1-18000)
(AIAA PAPER 86-1967)

A wing located in the wake of a propeller sustains unsteady loading. This loading can generate components of structureborne noise which are transmitted to the interior of the aircraft. The vibration of the wing can also contribute to reradiation of propeller noise. An analysis system for the evaluation of wing unsteady loads is presented. The propeller wake is modeled as a potential helical tip vortex and unsteady airfoil theory is used to determine the wing response. The result is the forcing function for determining the structureborne noise. The wing response is evaluated as a function of propeller thrust coefficient, advance ratio, and propeller installation geometry. The system capabilities are demonstrated by application to three significantly different aircraft. Author

**A86-45483*#** Missouri Univ., Rolla.

**A COMPARISON OF THE STRUCTUREBORNE AND AIRBORNE PATHS FOR PROPFAN INTERIOR NOISE**

W. EVERSMAN, J. V. RAMAKRISHNAN, and L. R. KOVAL (Missouri-Rolla, University, Rolla) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs
(Contract NAG1-394)
(AIAA PAPER 86-1863)

In the present comparative study of aircraft interior noise levels due to airborne and structureborne paths for a given propeller source, a structure model is used that treats the fuselage interior as a rectangular cavity with five rigid walls; the sixth, or fuselage sidewall, is a stiffened panel. The wing is modeled as a simple beam carried into the fuselage by a large, discrete stiffener representing the carry-through structure. Comparisons are made on the basis of interior noise over a range of propeller rotational frequencies at a fixed thrust. It is found that the relative importance

of the structural and airborne paths is highly dependent on the structural parameters.
O.C.

**A86-45749#**

### GROUND RESONANCE OF A HELICOPTER DURING THE TAKE-OFF AND LANDING RUN [REZONANS PRZYZIEMNY SMIGLOWCA PODCZAS ROZBIEGU]

L. ZEREK and D. DYMITRUK Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 102, 1985, p. 39-62. In Polish. refs

Fundamental problems of the analysis of the ground resonance of a helicopter during the takeoff and landing run are discussed, some physical and mathematical models of the phenomenon being put forward. The influence of the speed during the takeoff and landing run of a helicopter on its natural vibrations and the ground resonance is analyzed. The results of the analysis are presented in a graphical form.
Author

**A86-45750#**

### STATISTICAL ANALYSIS OF THE INFLUENCE OF SERVICE PARAMETERS ON THE AEROACOUSTIC EFFECTS [STATYSTYCZNA ANALIZA WPLYWU PARAMETROW EKSPLOATACYJNYCH NA EFEKTY AEROAKUSTYCZNE]

A. CHYLA Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 102, 1985, p. 63-90. In Polish. refs

The service parameters of light airscrew-propelled aircraft and helicopters constitute sets of multidimensional control vectors of complex dynamic objects. The present paper contains numerical data obtained for 19 types of helicopters and 265 types of airscrew-propelled aircraft which are used in various countries. The two sets of measurement results (noise levels) are treated as independent samples constituting parts of two populations. From those data it is inferred that there is an empirical dependence of the acoustic pressure, in the far acoustic field, on the service and design parameters. The models used have been verified by statistical methods, which make it possible to create an experimental model describing the noise produced irrespective of the type of the predominant source of noise, the influence of interference effects, the nonhomogeneity of flow and dynamic characteristics and the influence of the variation of velocity. Making use of the mathematical model it is possible to introduce some design modifications to reduce the noise.
Author

**A86-45753**

### CORPORATE FLYING, ITALIAN STYLE

A. POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 129, June 21, 1986, p. 42-45, 48, 49.

The P.180 Avanti 6-9 seat business aircraft, which uses a unique three-surface (canard-incorporating) configuration and highly contoured fuselage together with twin pusher turboprops for aerodynamic efficiency, is able to cruise at 400 kt, while burning half the fuel load of a comparable-payload jet. In addition, it will at $3.1 million cost only half as much as a jet aircraft. An exceptional effort has been made to insure laminar boundary flow over the greatest possible portions of the fuselage and wing. The structure is almost entirely metallic, with composites being confined to the control surfaces. Attention is presently given to the rationale for numerous design details, and their prospective performance advantages.
O.C.

**A86-45758**

### MORE THAN A MIRAGE

G. WARWICK Flight International (ISSN 0015-3710), vol. 129, June 28, 1986, p. 41-44.

The development status, design features, and performance capabilities of the next-generation French fighter, Rafale, are assessed. Rafale owes its distinctive appearance to a unique semiventral engine air intake design that has been optimized to allow the forward fuselage to deflect airflow into the inlets at the high-angle-of-attack regime typical of transonic combat maneuvering. Approximately 25 percent of the Rafale's structural weight is made up of composite materials, which are primarily carbon fiber-reinforced. Extensive comparisons are presently made with the Mirage 2000, to give perspective on the performance improvements that the Rafale promises. Twelve stores stations are evenly divided between wings and fuselage; two 30-mm cannon are carried internally. The Snecma M88 engine, whose thrust/weight of 9.5-10 compares with 7.5 for the F404 turbofan, will power propulsion versions of Rafale.
O.C.

**A86-46005**

### SOVIET ATTACK HELICOPTERS

J. W. R. TAYLOR Air International (ISSN 0306-5634), vol. 31, July 1986, p. 14-20.

The development status and future development prospects of Soviet attack helicopters are evaluated, with emphasis on the design features and performance capabilities of the Mil Mi-24 'Hind' variants currently in service with Warsaw Pact and Third World forces. More than 2300 Mi-24 helicopters are believed to have been delivered for service to date. Chemical weapons are regarded to be standard options for the latest variant, the Hind-D, which entered service in 1981. Attention is given to the variety and effectiveness of Mi-24 weapons, as well as to the results of preliminary assessments of the state-of-the-art Mi-28 'Havoc' dedicated attack helicopter and Kamov Ka-32 'Hokum' air-to-air combat helicopter.
O.C.

**A86-46125**

### A COME-BACK IN CANARDS

R. BRAYBROOK Air International (ISSN 0306-5634), vol. 30, June 1986, p. 267-276, 304-307.

A comprehensive discussion is presented concerning the design features and performance capabilities of state-of-the-art fighter aircraft employing canard configurations. The class encompasses both single and two-engined aircraft, and includes the Swedish JAS 39 Grippen, the French Rafale-A, the Israeli Lavi, the British EAP, and the inter-European EFA that is to be based on the EAP. The design trend is noted to have been instigated by the excellent performance established for the canard configuration by the Kfir derivative of the Mirage used by the Israeli Air Force and by the Swedish Viggen. All the aircraft in question are of multimission type, capable of both low altitude ground support/interdiction missions and air superiority/interception missions at high altitudes; all are, in addition, capable of supersonic speeds.
O.C.

**A86-46134**

### THE SKYEYE RPV - AN NDI SOLUTION TO TODAY'S UNMANNED AERIAL VEHICLE REQUIREMENTS

K. A. STANSELL (Lear Siegler, Inc., Developmental Sciences Astronics Div., Ontario, CA) Unmanned Systems, vol. 4, Spring 1986, p. 10, 11, 30.

Due to the sophistication of potential threat forces together with demands for reductions in defense spending, there is a renewed interest in the capabilities offered by unmanned aerial vehicle (UAV) systems. The development histories of the various members of the SKYEYE family are traced and their respective features are described. The SKYEYE R4E-40, the newest member of this family of unmanned aerial vehicles, offers a payload capacity of 140 pounds and a flight endurance exceeding eight hours. In late 1985, the SKYEYE was reconfigured to accommodate either a turreted daylight video or a turreted common module FLIR. It is noted that SKYEYE's success can be attributed to a great extent to its simplistic design and high degree of flexibility, both of which are reflected in the system's unique method of recovery. SKYEYE utilizes a shock-mounted centerline skid which requires no additional recovery equipment; it is also recoverable via a parachute system. The SKYEYE ground Control Station provides for command and control of the air vehicle and its payloads and accurate vehicle tracking and target positioning data.
K.K.

**A86-46153#**

### THE METHODS IMPLEMENTED AT ONERA TO IMPROVE AIRPLANE GROUND VIBRATION TESTS

R. DAT and P. LUBRINA (Union College, International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986) ONERA, TP, no. 1986-8, 1986, 7 p. refs
(ONERA, TP NO. 1986-8)

Test and data-analysis tecnniques developed to improve the efficiency and accuracy of aircraft ground vibration tests using the ONERA mobile test laboratory are described. The principles of the iterative algorithm of Dat and Dunoyer (1981) and Dat (1983) for the separation of modal transfer functions (SMTF), permitting vibration testing with white-noise excitation or only roughly tailored harmonic excitation, are explained, and a simplified version is applied to sample data for a Mystere 20 aircraft. The identification of weak nonlinearities by curve-fitting algorithms or by application of SMTF at different excitation levels is demonstrated, and it is shown that strong nonlinearities can be identified by vibration tests with the control surfaces disengaged, by superimposing high-frequency vibration, or by analysis of the response of the wing-driven control surface. T.K.

**A86-46177#**

### NEW MODAL IDENTIFICATION METHODS APPLIED TO AERONAUTICAL STRUCTURES

G. PIAZZOLI (ONERA, Chatillon-sous-Bagneux, France) and C. HUTIN (Societe pour le Perfectionnement des Materiels et Equipements Aerospatiaux, Velizy-Villacoublay, France) (NATO, AGARD, Specialists Meeting, Oslo, Norway, Apr. 13-18, 1986) ONERA, TP, no. 1986-35, 1986, 23 p. refs
(ONERA, TP NO. 1986-35)

Two ground vibration tests which are based on transfer functions analysis methods and nonappropriated excitation are presented. The first, the 'Separation of Modal Transfer Function' is based on multiexcitations which are monitored by independent coherent processes. The second, the 'multi-Excitation Method' is based on excitations monitored by noncoherent random processes. The results of tests performed on the Falcon aircraft are compared with those of the classical method and a critical analysis is made; problems such as the nonlinearities of aircraft structures are taken into consideration. K.K.

**A86-46198#**

### AERODYNAMIC TECHNOLOGIES FOR GENERAL AVIATION AIRCRAFT

W. SCHMIDT Dornier Post (English Edition) (ISSN 0012-5563), no. 2, 1986, p. 18-20.

The development of the Dornier 228 aircraft is used to illustrate techniques which can ensure that new general aircraft satisfy performance and production cost goals for such aircraft. The important performance characteristics of such aircraft are range, single engine climb rate and minimum speed. The design goals are thus maximized L/D, cruise efficiency, climb parameter and high propeller efficiency. Computational fluid dynamics studies permit identification of fuselage designs that, in the case of the 228, offered a 15 percent decrease in drag from a previous generation of aircraft. The use of fiber-reinforced composites in the wings permits maintenance of laminar flow up to 60 percent of the chord. Variable camber was identified as a means to extend the shape control capability. Efficiency, i.e., fuel savings, was also realized with low drag propulsion integration, and it is expected that advanced propellers and propfans will provide even greater efficiency enhancements. M.S.K.

**A86-46405**

### AVANTI TO FLY SOON

M. GRANGIER Interavia (ISSN 0020-5168), vol. 16, June 1986, p. 645-647.

An assessment is made of the development status and marketing prospects of the 'Avanti' two-crew/six to nine-passenger twin-turboprop aircraft. The Avanti features an aerodynamically contoured fuselage and canard configuration, whose aerodynamic efficiencies yield a 1000-nmi range at 400-kt maximum cruising speed with six onboard. Cabin dimension and performance comparisons are tabulated for the Avanti and its competitors, the Starship I, Citation S/II, Cheyenne 400LS, and King Air 300. Projections are presented for the Avanti's cruising speed vs. altitude and IFR range/payload ratio performance. O.C.

**A86-46458#**

### PRACTICAL CONSIDERATIONS IN OPTIMAL FLIGHT MANAGEMENT COMPUTATIONS

S. LIDEN (Sperry Corp., Aerospace and Marine Group, Phoenix, AZ) (1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2, p. 675-681) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 427-432. Previously cited in issue 15, p. 2128, Accession no. A86-35367. refs

**A86-46461*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### IDENTIFICATION AND VERIFICATION OF FREQUENCY-DOMAIN MODELS FOR XV-15 TILT-ROTOR AIRCRAFT DYNAMICS IN CRUISING FLIGHT

M. B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), J. G. M. LEUNG, and D. C. DUGAN (NASA, Ames Research Center, Moffett Field, CA) (International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. 17 p.) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 446-453. Previously cited in issue 11, p. 1481, Accession no. A86-27661. refs

**A86-46850**

### AIRCRAFT HYDRAULIC SYSTEMS: AN INTRODUCTION TO THE ANALYSIS OF SYSTEMS AND COMPONENTS

W. L. GREEN (Salford, University, England) Chichester, England and New York, Wiley-Interscience, 1985, 150 p. refs

The presently treated design practices associated with aircraft hydraulic systems and their components must meet the most severe constraints imposed by airworthiness requirements, environmental restrictions, and reliability criteria. Attention is given to hydraulic valves for control of flow direction and of flow speed and maximum pressure; fluid power circuits, emergency operation, and accumulator performance, servovalves, servoflying control units; fluid compressibility, liquid springs and their natural frequencies, hydraulic servos, Bode diagrams for harmonic response, electrohydraulic servos, and the relationships among stability networks, on-off servos, and nonlinearities. O.C.

**A86-47096**

### A COMPARISON OF METHODS FOR AIRCRAFT GROUND VIBRATION TESTING

D. L. HUNT (SDRC, Inc., Milford, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1 . Schenectady, NY, Union College, 1985, p. 131-137. refs

The recent advances in multiple-input techniques for experimental modal analysis have given the test engineer alternatives for performing aircraft ground vibration tests (GVT). Multiple-input random excitation is one of the methods being used instead of the traditional sine dwell approach. The relative advantages of the random and sine methods are apparent in comparisons made using data from recent aircraft GVT's. Author

**A86-47128**

### DYNAMIC AND FLUTTER ANALYSIS USING F.E.M. OF THE GP-180

A. MAZZONI and M. PIZZAMIGLIO (Rinaldo Piaggio Industrie Aeronautiche e Meccaniche S.p.A., Finale Ligure, Italy) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2 . Schenectady, NY, Union College, 1985, p. 1162-1170.

Three steps have been followed for the GP-180 dynamic and flutter analyses. After a preliminary investigation of the GP-180 characteristics, using a simple beam finite element model, a detailed

analysis has been performed using the static model. The last verification of the results was done in the wind tunnel, using an aeroelastic model. This was based on a simple beam model, having the same characteristic about stiffnesses, mass, inertia, and in particular about mode shapes and flutter behavior of the detailed model.
Author

**N86-29809*#** Stanford Univ., Calif.
**OPTIMAL LANDING OF A HELICOPTER IN AUTOROTATION**
A. Y. N. LEE Jul. 1985 322 p
(Contract NCC2-106)
(NASA-CR-177082; NAS 1.26:177082) Avail: NTIS HC A14/MF A01 CSCL 01C

Gliding descent in autorotation is a maneuver used by helicopter pilots in case of engine failure. The landing of a helicopter in autorotation is formulated as a nonlinear optimal control problem. The OH-58A helicopter was used. Helicopter vertical and horizontal velocities, vertical and horizontal displacement, and the rotor angle speed were modeled. An empirical approximation for the induced velocty in the vortex-ring state were provided. The cost function of the optimal control problem is a weighted sum of the squared horizontal and vertical components of the helicopter velocity at touchdown. Optimal trajectories are calculated for entry conditions well within the horizontal-vertical restriction curve, with the helicopter initially in hover or forwared flight. The resultant two-point boundary value problem with path equality constraints was successfully solved using the Sequential Gradient Restoration Technique.
Author

**N86-29810*#** Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechani
**FLAP-LAG-TORSIONAL DYNAMICS OF HELICOPTER ROTOR BLADES IN FORWARD FLIGHT Final Report, Jan. 1984 - Jun. 1986**
M. R. M. CRESPODASILVA Jun. 1986 6 p
(Contract NAG2-274)
(NASA-CR-176976; NAS 1.26:176976) Avail: NTIS HC A02/MF A01 CSCL 01C

A perturbation/numerical methodology to analyze the flap-lead/lag motion of a centrally hinged spring restrained rotor blade that is valid for both hover and for forward flight was developed. The derivation of the nonlinear differential equations of motion and the analysis of the stability of the steady state response of the blade were conducted entirely in a Symbolics 3670 Machine using MACSYMA to perform all the lengthy symbolic manipulations. It also includes generation of the fortran codes and plots of the results. The Floquet theory was also applied to the differential equations of motion in order to compare results with those obtained from the perturbation analysis. The results obtained from the perturbation methodology and from Floquet theory were found to be very close to each other, which demonstrates the usefulness of the perturbation methodology. Another problem under study consisted in the analysis of the influence of higher order terms in the response and stability of a flexible rotor blade in forward flight using Computerized Symbolic Manipulation and a perturbation technique to bypass the Floquet theory. The derivation of the partial differential equations of motion is presented.
B.G.

**N86-29811*#** Bio-Dynamics Research and Development Corp., Eugene, Oreg.
**FEASIBILITY STUDY FOR ERGONOMIC ANALYSIS AND DESIGN OF FUTURE HELICOPTER COCKPIT SYSTEMS**
H. L. HAWKINS May 1985 52 p
(Contract NAS2-12056)
(NASA-CR-176942; NAS 1.26:176942) Avail: NTIS HC A04/MF A01 CSCL 01C

The Army's light scout-attack helicopters (LHXs), planned for deployment in the 1990's, will fly nap-of-the-earth (NOE) missions in high threat environments, often under poor visibility and adverse atmospheric conditions, and probably with a one man crew. A procedure for the analysis of pilot workload that will identify and explicate the main characteristics of those LHX mission components holding overload potential is described. A principled, in-depth, explication of the cognitive demans of LHX piloting is essential to any effective effort to address the human factors issues. A task-analytic procedure that will yield the detail and organizstion needed to achieve these goals is examined.
B.G.

**N86-29812*#** Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
**STUDY OF NEW FLIGHT TEST TECHNIQUES Final Report**
D. DEAM Aug. 1984 29 p
(Contract NSG-4019)
(NASA-CR-176952; NAS 1.26:176952; KU-FRL-407-10) Avail: NTIS HC A03/MF A01 CSCL 01C

The modification and testing of a small electromechanical vibrator are described. The vibrator was designed for the flutter testing of aircraft wings and was built to specifications that make it compatible with the X-29 experimental aircraft. The device uses alternating electromagnetic forces to move a magnetic mass and produce vibration. Its unconventional way of producing vibration avoids the need for complex mechanisms and makes efficient use of space and weight.
B.G.

**N86-29813*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**FLIGHT CONTROL SYSTEM DEVELOPMENT AND FLIGHT TEST EXPERIENCE WITH THE F-111 MISSION ADAPTIVE WING AIRCRAFT**
R. R. LARSON Aug. 1986 21 p To be presented at the AIAA Guidance, Navigation, and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88265; H-1366; NAS 1.15:88265; AIAA-86-2237-CP) Avail: NTIS HC A02/MF A01 CSCL 01C

The wing on the NASA F-111 transonic aircraft technology airplane was modified to provide flexible leading and trailing edge flaps. This wing is known as the mission adaptive wing (MAW) because aerodynamic efficiency can be maintained at all speeds. Unlike a conventional wing, the MAW has no spoilers, external flap hinges, or fairings to break the smooth contour. The leading edge flaps and three-segment trailing edge flaps are controlled by a redundant fly-by-wire control system that features a dual digital primary system architecture providing roll and symmetric commands to the MAW control surfaces. A segregated analog backup system is provided in the event of a primary system failure. This paper discusses the design, development, testing, qualification, and flight test experience of the MAW primary and backup flight control systems.
Author

**N86-29814*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**FLIGHT TEST OF A DECOUPLER PYLON FOR WING/STORE FLUTTER SUPPRESSION**
F. W. CAZIER, JR. and M. W. KEHOE (National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.) Jul. 1986 14 p Presented at the AIAA 3rd Flight Testing Conference, Las Vegas, Nev., 2-4 Apr. 1986
(NASA-TM-87767; NAS 1.15:87767) Avail: NTIS HC A02/MF A01 CSCL 01B

The decoupler pylon is a NASA concept of passive wing-store flutter suppression achieved by providing a low store-pylon pitch frequency. Flight tests were performed on an F-16 aircraft carrying on each wing an AIM-9J wingtip missile, a GBU-8 bomb near midspan, and an external fuel tank. Baseline flights with the GBU-8 mounted on a standard pylon established that this configuration is characterized by an antisymmetric limited amplitude flutter oscillation within the operational envelope. The airplane was then flown with the GBU-8 mounted on the decoupler pylon. The decoupler pylon successfully suppressed wing-store flutter throughout the flight envelope. A 37-percent increase in flutter velocity over the standard pylon was demonstrated. Maneuvers with load factors to 4g were performed. Although the static store displacements during maneuvers were not sufficiently large to be of concern, a store pitch alignment system was tested and performed successfully. One GBU-8 was ejected demonstrating that weapon separation from the decoupler pylon is normal. Experience with the present decoupler pylon design indicated that friction in the pivoting mechanism could affect its proper functioning as a flutter suppressor. Author

**N86-29815*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**DESIGN AND FABRICATION OF LARGE SUCTION PANELS WITH PERFORATED SURFACES FOR LAMINAR FLOW CONTROL TESTING IN A TRANSONIC WIND TUNNEL**
D. V. MADDALON and W. A. POPPEN, JR. Aug. 1986 67 p
(NASA-TM-89011; NAS 1.15:89011) Avail: NTIS HC A04/MF A01 CSCL 01C

Considerable progress has been made in the development of perforated suction surface material for laminar flow control applications. Electron-beam perforated titaniuum skin was used as the suction surface. Critical issues related to suction panel manufacturing were identified and largely resolved. The final product included fabrication of a 7-foot chord by 7-foot span perforated laminar flow control wind tunnel model. Techniques used can be adapted to modern aircraft production lines. The report includes details on panel instrumentation and other features required for testing in a transonic pressure tunnel. Author

**N86-30654#** Grumman Aerospace Corp., Bethpage, N.Y.
**THE APPLICATION OF PRACTICAL OPTIMIZATION TECHNIQUES IN THE PRELIMINARY STRUCTURAL DESIGN OF A FORWARD-SWEPT WING**
E. LERNER *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 381-392 1985
Avail: NTIS HC A99/MF E03

The application of optimization technology in design studies that preceded the full development of the Grumman X-29, forward swept wing, demonstrator aircraft is outlined. Finite-element resizing methods were developed to satisfy optimality criteria for strength and divergence-velocity constraints. Application of the methods in an initial feasibility study of a variable sweep wing and in a more detailed, fixed wing design study are described. The usefulness of the methodology at various stages of design in demonstrated by tracing the process that led to the selection of an efficient cover-laminate configuration. ESA

**N86-30655#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
**STRUCTURAL OPTIMIZATION PROGRAMS AND METHODS**
A. J. MORRIS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 393-406 1985
Avail: NTIS HC A99/MF E03

Minimum weight design algorithms used in computer aided aircraft design are reviewed. Applications to carbon fiber composite wings, aircraft flaps, fuselages, and an automobile seat are illustrated. ESA

**N86-30656#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
**VARIATION OF ANISOTROPIC BEHAVIOR IN STRUCTURAL OPTIMIZATION**
G. HORNUNG, D. W. MATHIAS, and H. ROEHRLE *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 407-414 1985
Avail: NTIS HC A99/MF E03

Use of the gradient method to optimize carbon fiber reinforced composite airframe design is described. The optimization process consists of two major parts. The first part of the calculation is done to select the fiber orientations for a given structure under a given load. In the second part this preoptimized configuration is improved by varying the thicknesses of the layers, leading to the optimum design. This design having preoptimized compounds is compared with a corresponding quasiisotropic structure and a design having four fixed fiber directions but different thicknesses of the layers. The preoptimized design is shown to be best adapted to the load bearing requirements of the structure. ESA

**N86-30660#** Tel-Aviv Univ. (Israel). Faculty of Engineering.
**RECENT RESULTS ON THE WEIGHT MINIMIZATION OF PANELS WITH A FLUTTER SPEED CONSTRAINT**
L. LIBRESCU and L. BEINER *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 441-450 1985
Avail: NTIS HC A99/MF E03

Weight minimization of flat and curved panels exposed to a supersonic flow and subjected to a flutter speed constraint is described. The analysis encompasses axisymmetric circular cylindrical shells and rectangular orthotropic flat panels. Optimal control in a single variable and of distributed parameter systems is used in deriving the optimality equations. in order to ensure that the flutter speed of the optimal panel coincides with the constrained one, a flutter instability condition is employed. Galerkin's technique is used for solving the optimality equations and the influence of orthotropicity ratio, in-plane loads, aspect ratio, and boundary conditions on the optimal thickness distribution is determined. For the case of pure transverse shear panels, an aeroelastic paradox similar to the membrane paradox is revealed. The cases of 1-D type panels and isotropic 2-D panels are also considered. ESA

**N86-30662#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
**AEROELASTIC PROBLEMS AND STRUCTURAL DESIGN OF A TAILLESS CARBON FIBER COMPOSITE (CFC) SAILPLANE**
J. SCHWEIGER, O. SENSBURG, and H. J. BERNS (Technische Univ., Brunswick, West Germany) *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 457-468 1985
Avail: NTIS HC A99/MF E03

Severe instability at low speed in a 1/3 scale model of a 15 m sailplane was studied. Flutter calculations using data from a ground resonance test show that coupling of the rigid body short period mode with the first elastic mode causes the phemomenon. The wing was redesigned with the optimization programs FASTOP and TSO to find optimum fiber orientations and stiffness distributions for aeroelastic and strength requirements. By applying these computer codes the flutter speed is increased to an acceptable level with small modifications of the wing root geometry, a new design of the main spar, and by using a high modulus fiber type. With a small weight penalty compared to the initial design the flutter speed can be doubled. ESA

**N86-30665#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
**STRUCTURAL DYNAMIC ASPECTS OF ROTOR NODAL ISOLATION**
J. STOPPEL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 486-494 1985
Avail: NTIS HC A99/MF E03

An Antiresonance Isolation System (ARIS) for helicopters is described. In the passive nodal isolation system, the antiresonant frequency is tuned to the main rotor passage frequency to prevent the transmission of the oscillatory hub forces and moments to the fuselage. Analysis demonstrates that the nodal rotor isolation system may be strongly influenced by the structural dynamics of the helicopter. Due to the numerous eingenvalues the antiresonant frequency of the isolation system may be compensated by an adjacent natural frequency. In this case the desired isolating effect disappears. The complexity of the three dimensional structure aggravates the understanding and prediction of vibration system. For the BK 117 helicopter with MBB-ARIS, the structural optimization is demonstrated using finite element methods. ESA

**N86-30678#** Northwestern Polytechnical Univ., Xian (China). Dept. of Aircraft Engineering.

**DETERMINATION OF NATURAL VIBRATION PROPERTIES OF A WING WITH WINGLET BY EXPERIMENTAL MODE SYNTHESIS TECHNIQUE**

S. N. GU, W. J. YOU, and J. S. JIANG *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 605-611 1985

Avail: NTIS HC A99/MF E03

Nine lowest natural frequencies and their corresponding natural modes of a wing model with winglet were determined using electric measurement and laser time-averaged holographic interferometry supplemented by sand contours. Three-dimensional quantitative analysis and orthogonalization of the three lowest natural modes of wing with winglet are carried out. Modal synthesis is used to get lower ordered natural frequencies and modes of the wing model with winglet, by using the six lowest orthogonalized modes of the wing and three lowest orthogonalized modes of the winglet. Calculated results of natural frequencies and modes of the wing with winglet and its wing by finite element method agree quite well with experimental data. ESA

**N86-30679#** Israel Aircraft Industries Ltd., Ben-Gurion Airport.

**RAPID VIBRATION MODE ANALYSIS OF AIRCRAFT WITH EXTERNAL STORES**

M. KARPEL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 612-616 1985

Avail: NTIS HC A99/MF E03

A method for coupling the vibration modes of a central structure to additional substructures is presented. A set of low frequency natural modes, including rigid body modes, represents the central structure. These modes are obtained by a mathematical model loaded with a set of fictitious masses at the connection to the substructures degrees of freedom. The substructures are represented by their mass properties, vibration modes with clamped boundary conditions and free-free rigid body modes. The connection of each substructure to the central structure is statically determinate. The method is applied for vibration analysis of aircraft with external stores. The coupled aircraft + stores dynamic properties may be efficiently used for flutter analysis. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results with low order eigensolutions. ESA

**N86-30718*#** California Univ., Los Angeles. Dept. of Computer Science.

**A.I.-BASED REAL-TIME SUPPORT FOR HIGH PERFORMANCE AIRCRAFT OPERATIONS Report, 15 May 1984 - 14 May 1985**

J. VIDAL, J. 1985 52 p

(Contract NAG2-302)

(NASA-CR-176906; NAS 1.26:176906) Avail: NTIS HC A04/MF A01 CSCL 01C

Artificial intelligence (AI) based software and hardware concepts are applied to the handling system malfunctions during flight tests. A representation of malfunction procedure logic using Boolean normal forms are presented. The representation facilitates the automation of malfunction procedures and provides easy testing for the embedded rules. It also forms a potential basis for a parallel implementation in logic hardware. The extraction of logic control rules, from dynamic simulation and their adaptive revision after partial failure are examined. It uses a simplified 2-dimensional aircraft model with a controller that adaptively extracts control rules for directional thrust that satisfies a navigational goal without exceeding pre-established position and velocity limits. Failure recovery (rule adjusting) is examined after partial actuator failure. While this experiment was performed with primitive aircraft and mission models, it illustrates an important paradigm and provided complexity extrapolations for the proposed extraction of expertise from simulation, as discussed. The use of relaxation and inexact reasoning in expert systems was also investigated. Author

**N86-30719#** Federal Aviation Administration, Washington, D.C.

**ADVISORY CIRCULAR: AUXILIARY FUEL SYSTEM INSTALLATIONS**

2 May 1986 53 p

(FAA/AC-25-8) Avail: NTIS HC A04/MF A01

The advisory circular (AC) provides guidance and criteria for the installation of auxiliary fuel systems, i.e., those which supplement essential fuel systems to provide additional range, in transport category airplanes. It is intended primarily for installations in which the auxiliary fuel is carried with the fuselage, such as within cargo or baggage compartments, the main deck or other similar areas. B.G.

**N86-30720*#** National Aeronautics and Space Administration, Washington, D.C.

**NASA AND GENERAL AVIATION**

J. L. ETHELL 1986 140 p Original contains color illustrations

(NASA-SP-485; NAS 1.19:485) Avail: NTIS HC A07/MF A01 CSCL 01C

General aviation remains the single most misunderstood sector of aeronautics in the United States. A detailed look at how general aviation functions and how NASA helps keep it on the cutting edge of technology in airfoils, airframes, commuter travel, environmental concerns, engines, propellers, air traffic control, agricultural development, electronics, and safety is given. Author

**N86-30721*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IMPACT DATA FROM A TRANSPORT AIRCRAFT DURING A CONTROLLED IMPACT DEMONSTRATION**

E. L. FASANELLA (PRC Kentron, Inc., Hampton, Va.), E. ALFARO-BOU, and R. J. HAYDUK Sep. 1986 88 p

(NASA-TP-2589; L-16125; NAS 1.60:2589) Avail: NTIS HC A05/MF A01 CSCL 01B

On December 1, 1984, the FAA and NASA conducted a remotely piloted air-to-ground crash test of a Boeing 720 transport aircraft instrumented to measure crash loads of the structure and the anthropomorphic dummy passengers. Over 330 time histories of accelerations and loads collected during the Full-Scale Transport Controlled Impact Demonstration (CID) for the 1-sec period after initial impact are presented. Although a symmetric 1 deg. nose-up attitude with a 17 ft/sec sink rate was planned, the plane was yawed and rolled 13 deg. at initial (left-wing) impact. The first fuselage impact occurred near the nose wheel well with the nose pitched down 2.5 deg. Peak normal (vertical) floor accelerations were highest in the cockpit and forward cabin near the nose wheel well and were approximately 14G. The remaining cabin floor received normal acceleration peaks of 7G or less. The peak longitudinal floor accelerations showed a similar distribution, with the highest (7G) in the cockpit and forward cabin, decreasing to 4G or less toward the rear. Peak transverse floor accelerations ranged from about 5G in the cockpit to 1G in the aft fuselage. Author

**N86-30722*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**THE PERFORMANCE EVALUATION OF A JET FLAP ON AN ADVANCED SUPERSONIC HARRIER Final Report**

L. D. LIPERA and D. R. SANDLIN Aug. 1984 84 p

(Contract NCC2-238)

(NASA-CR-179653; NAS 1.26:179653) Avail: NTIS HC A05/MF A01 CSCL 01C

The performance concept of a supersonic vertical and short takeoff and landing (V/STOL) fighter, model 279-3, modified to utilize a jet flap was evaluated. Replacing the rear nozzles of the 279-3 with the jet flap favorably alters the pressure distribution over the airfoil and dramatically increases lift. The result is a significant decrease in takeoff distance, an increase in payload, and an improvement in combat performance. To investigate the benefit in increased payload, the 279-3 and the jet flapped 279-3JF were modeled on the NASA Aircraft Synthesis (ACSYNT) computer code and flown on a 250 feet takeoff distance interdiction mission. The increase in payload weight that the 279-3JF could carry was converted into fuel in one case, and in another, converted to bomb load. When the fuel was increased, the 279-3JF penetrated into enemy territory almost four times the distance of 279-3, and therefore increased mission capability. When the bomb load was increased, the 279-3JF carried 14 bombs the same distance the 279-3 carried four. The increase in mission performance and improvements in turning rates was realized with only a small penalty in increased empty weight. Author

**N86-30723*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
**MODIFIED US ARMY U-8F GROUND VIBRATION TEST**
M. W. KEHOE Aug. 1986 50 p
(NASA-TM-86741; H-1297; NAS 1.15:86741) Avail: NTIS HC A03/MF A01 CSCL 01C

The Dryden Flight Research Facility of NASA Ames Research Center conducted a ground vibration test on a modified U.S. Army U-8F airplane. Modifications included new engines, propellers, and engine-mounted truss assemblies. The ground vibration test was conducted using sine dwell, single-point random, and impact excitations. The test was performed to determine modal frequencies, mode shapes, and structural damping coefficients of the airframe and propeller with full and empty fuel tanks. The data presented include frequency response plots, rigid-body and structural modal frequencies, and mode shapes. Author

**N86-30724#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
**LIQUID HYDROGEN FUELED PASSENGER AIRCRAFT**
Y. QIAN 11 Mar. 1986 11 p Transl. into ENGLISH from Hangkong Zhishi (China), no. 11, Nov. 1984 p 22-23
(AD-A166229; FTD-ID(RS)T-0862-85) Avail: NTIS HC A02/MF A01 CSCL 01C

The idea that passenger aircraft will eventually use liquid hydrogen fuel is discussed. There is a large reserve of hydrogen and hydrogen poses no danger to the environment. Hydrogen has high calorific value, high specific heat, low density and low temperature. Aircraft will have to have a liquid fuel tank to carry the hydrogen and will have to be partially redesigned. Lockheed and NASA have considered such designs. A problem remains in the planning--the high cost of large extraction of liquid hydrogen. GRA

**N86-30725#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**ELECTROSTATIC HAZARDS OF URETHANE PACKED FUEL TANKS Final Report, Mar. 1977 - Apr. 1978**
T. C. HILLMAN, J. R. MANHEIM, and G. A. SPENCER Mar. 1986 95 p
(AD-A166803; AFWAL-TR-82-2022) Avail: NTIS HC A05/MF A01 CSCL 13L

An experiment investigation has been been carried out to determine the primary factors that have contributed to recent aircraft electrostatically induced ground refueling fire incidents. It was found that the explosion suppression open pore polyurethane fuel tank foams along with the charging characteristics of the JP-4 fuel resulted in charge accumulation and electrostatic spark discharging. The polyurethane foams accumulated charge due to their highly resistive nature (blue, 10 to the 15th power ohm-cm; red, 10 to the 14th power ohm-cm; yellow, to the 14th power ohm-cm; and orange, 10 to the 13th power ohm-cm). The fuel flow rate and velocity entering the tank and impinging on the open pore polyurethane foam directly affected the magnitude of the charge separation which was occurring. The number of refuelings that had taken place also was a critical factor due to its effect on charge accumulation/discharge frequency levels. The last major variable investigated was pro-static (Gulf-178) and conductivity improving (shell ASA-3) fuel additives. The Gulf-178 additive dramatically increased the levels of charge separation and accumulation taking place along with a reversal in the polarity of charge. The Shell ASA-3 fuel additive eliminated the aircraft ground refueling electrostatic discharge hazard decreasing the level of charge accumulation. GRA

**N86-30726#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Strucutures and Materials Panel.
**THE INFLUENCE OF LARGE-SCALE COMPUTING ON AIRCRAFT STRUCTURAL DESIGN**
Apr. 1986 67 p
(AGARD-R-726; ISBN92-835-1522-6) Avail: NTIS HC A04/MF A01

An outcome of the AGARD Working Group on Large Scale Computing was the institution by the Structures and Materials Panel of a Sub-Committee to consider this topic in relation to Aircraft Structural design. The publication contains papers on various aspects of the topic heard by the Sub-Committee plus a summary. These cover likely developments in both soft- and hardware, and their applications to the Design process. This Report was sponsored by the Structures and Materials Panel of AGARD. Author

**N86-30727#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**STORE SEPARATION FLIGHT TESTING**
R. J. ARNOLD, C. S. EPSTEIN, and R. K. BOGUE, ed. Apr. 1986 161 p
(AGARD-AG-300-VOL-5; ISBN92-835-1523-4) Avail: NTIS HC A08/MF A01

This volume in the AGARD Flight Test Techniques Series treats stores separation testing from the overall systems standpoint. All aspects of testing are described from the time of identification of a particular aircraft/store requirement through all steps leading to the establishment of a satisfactory employment envelope. Considerable emphasis is placed on the planning and execution of the flight test phase of the stores clearance program, including the definition of a basic structure, and a set of procedures which will maximize the safe and efficient execution of such a program. Author

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-43481#**
**IDENTIFICATION AND ESTIMATION OF THE RANDOM ERROR MODELS FOR INERTIAL ACCELEROMETER AND BARO-ALTIMETER**
R. WANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 556-564. In Chinese, with abstract in English. refs

In accordance with the 'Flight Control' (SFB-58 Flugfuehrung) national research project in West Germany, it is necessary to develop an optimal baroradioinertial hybrid altimeter for the research aircraft DO-28. For this purpose, the random error models for vertical accelerometers on inertial platform and a barometric altimeter under the conditions of landing approach are identified and estimated with the aid of two onboard data acquisition systems. The optimal estimate of the ARIMA model of the associatd random error sources is obtained by the time series analysis. A number of actual problems, such as data preprocessing and effect of measurement noise on error model, are also discussed. Author

**A86-45066**
**BOEING DEVELOPING NEW COCKPIT DISPLAYS TO EASE PILOT WORKLOAD**
J. T. MERRIFIELD Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 109, 110, 113.

A program being pursued to ready advanced cockpit displays and automated systems in order to manage the large volume of information that will be available to pilots of the USAF's advanced tactical fighter (ATF) is discussed. In the pictorial format cockpit concept being utilized, the ATF pilot will be assisted by an 'electronic copilot' equipped to automatically handle such tasks as flight and powerplant control, weapons management, and countermeasures. The system would also manage communications and navigation systems while informing the pilot of current tactical situations and advising him in the decision-making process. The research funding for this effort is discussed, and the simulation equipment utilized is described. The roles of the crew station information manager in the system is addressed, including his interaction with the pilot. A planned Kickoff demonstration of the system is described, and related developments in avionics are summarized. C.D.

**A86-45067**

### CREW SITUATIONAL AWARENESS DRIVES AVIONICS DEVELOPMENTS

M. A. DORNHEIM Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 114-116.

Avionics research being conducted to provide increased tactical situation awareness for fighter crews is discussed. The main aspects of situational awareness, finding targets while minimizing emissions, identifying targets, and displaying the information to the pilot, are discussed in terms of the display technology required. The features of a conceptual 'supercockpit' which will provide superior situational awareness are addressed, using the visually coupled airborne systems simulator (VCASS) as an example. The use of avionics modularity to control manufacturing costs and logistics is discussed, stressing the importance of reliability. The maintainability of these avionics systems is also discussed. C.D.

**A86-45209**

### THE ACCURACY OF AIR-TEMPERATURE AND FLIGHT-ALTITUDE MEASUREMENTS ABOARD METEOROLOGICAL AIRCRAFT [O TOCHNOSTI IZMERENIIA TEMPERATURY VOZDUKHA I VYSOTY POLETA NA SAMOLETAKH-METEOLABORATORIIAKH]

V. P. BELIAEV IN: Methods and technology for experimental studies of the atmosphere . Moscow, Gidrometeoizdat, 1985, p. 113-122. In Russian. refs

Measurement errors in determinations of air temperature, air speed, and flight altitude by means of airborne meteorological instruments are discussed. Data obtained by using different instruments to determine a given parameter are compared with one other and with radio-sounding data. For temperature measurements, a thermometer with a shielded thermal element is recommended to eliminate the cloud effect. It is also advisable to use the most exact equations, rather than approximating relationships, for calculations of flight altitude and air velocity, utilizing an airborne digital computer. I.S.

**A86-46139**

### WIND-SHEAR DETECTION - A REPORT ON THE FIRST SUCH AIRBORNE WARNING DEVICE TO BE COMMERCIALLY CERTIFIED

B. C. JOHNSTON (Sperry Corp., New York) ICAO Bulletin, vol. 41, March 1986, p. 14-17.

The Performance Management System (PMS) which contains an airborne wind shear detection and alert system is described. The main components of the alert system are a wind-shear computer and a detector. The system evaluates changes in the inertial and air-mass accelerations of aircraft and the annunciation of wind shear is provided to the flight crew using the PMS performance management indicator, a light on the PMS speed deviation indicator, and a flashing red lamp alert. The performance of the wind shear detection and alert system is tested using models and flight tests; it is observed that the system provides accurate and reliable wind shear data. The installation of a program into the system that will supply instructions to the crew on how to exit the wind shear is examined. I.F.

**A86-46141**

### TRENDS IN CIVIL AVIONICS FOR THE NEAR FUTURE

M. VIVET (Telecommunications Radioelectriques et Telephoniques, Paris, France) ICAO Bulletin, vol. 41, March 1986, p. 22-24.

The growth of avionics is examined. The early development of avionics equipment (1910-1940) is discussed. The use of transistors, semiconductors, and solid-state circuits in airborne equipment is described. The advantages of digital technology as compared to analog technology are studied. The present utilization of electronics and computers in integrated avionics equipment is analyzed. The digitalization of information and data processing methods, decreases in avionics maintenance costs, improvements in communication systems, and an automatic data management concept are proposed for future avionics systems. I.F.

**A86-46150**

### LIQUID-CRYSTAL GOGGLES PERMIT VISUAL SIMULATIONS OF RESTRICTED VISIBILITY

F. A. WATT, III (Instrument Flight Research, Inc., West Columbia, SC) ICAO Bulletin, vol. 41, May 1986, p. 34-36.

The present Instrument Meteorological Conditions Simulator reproduces the weather conditions seen by a pilot by means of a pair or liquid crystal lenses having electrically controllable opacity. The system encompasses a set of electronically controlled goggles worn by the trainee pilot and a controller subsystem that is operated by the instructor/safety pilot. The goggles may be worn on helicopter or aircraft helmets, or directly on the pilot's face. When simulating clouds or fog, the goggles reproduce the effect of a progressive obscuration of objects with increasing distance from the viewer. O.C.

**A86-46676*** Georgia Inst. of Tech., Atlanta.

### AN UPWARD LOOKING AIRBORNE MILLIMETER WAVE RADIOMETER FOR ATMOSPHERIC WATER VAPOR SOUNDING AND RAIN DETECTION

J. A. GAGLIANO and R. H. PLATT (Georgia Institute of Technology, Atlanta) IN: Millimeter wave technology III; Proceedings of the Meeting, Arlington, VA, April 9, 10, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 112-117. refs

(Contract NAS5-28132; NAS5-28724)

A 90/180 GHz multichannel radiometer is currently under development for NASA's 1985 Hurricane Mission onboard the Convair 990 research aircraft. The radiometer will be a fixed beam instrument with dual corrugated horns and a common lens antenna designed to operate simultaneously at 90 and 180 GHz. The all solid state front-end will contain three double side band data channels at 90 + or - 3 GHz, 180 + or - 3 GHz, and 180 + or - 7 GHz. The airborne radiometer will mount in a window port on the CV-990 and will maintain a fixed beam view approximately 14 degrees off zenith. The radiometer design is a Dicke chopper arrangement selected to achieve maximum absolute temperature accuracy and minimum brightness temperature sensitivity. Analog outputs of the three data channels will be calibrated dc voltages representing the observed radiometric brightness temperatures over the selected integration time. Author

**A86-46715**

### DECISION AIDING FOR TACTICAL AIRCRAFT

M. BROADWELL, J. SMITH, J. BARNETTE, and C. STAROS (Lockheed-Georgia Co., Advanced Electronics Div., Marietta) IN: Applications of artificial intelligence II; Proceedings of the Meeting, Arlington, VA, April 9-11, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 153-160. refs

Some of the tasks of the airborne mission/route planner system under development for tactical aircraft require symbolic reasoning on the basis of subjective and incomplete information. Other tasks call for precise and synchronized processing of aircraft control parameters, while others may be of a nature that is intermediate between the two extremes. Attention is given to this system's design and implementation approach, which involves the subdivision of the route planning problem into a hierarchy of reasoning abstractions reflecting the types of reasoning or

computation best suited to the various facets of the problem.
O.C.

**A86-47106**

### AN INTELLIGENT AMPLIFIER AND ITS APPLICATION TO MODAL TESTING

R. D. TALMADGE (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1 . Schenectady, NY, Union College, 1985, p. 507-510.

The design of the automatic gain ranging amplifier (AGRA) which is to provide the gain element in a data collection system is examined. The amplifier consists of a gain block, a presample filter with six poles and butterworth characteristics, a quasi-peak detector for gain control, and a line driver output. The use of a dual-tracking constant-current-circuit to supply bridge power and measure the differential IR drops across the elements is discussed. The performance characteristics and functions of the digitally contolled AGRA are described. The AGRA produces an analog signal output. The application of the amplifier to flight and ground testing of aircraft is analyzed.
I.F.

**N86-29816#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.

### ANALOGUE SIGNAL CONDITIONING FOR FLIGHT TEST INSTRUMENTATION

D. W. VEATCH and R. BOGUE Apr. 1986 179 p
(AGARD-AG-160-VOL-17; ISBN-92-835-1520-X) Avail: NTIS HC A09/MF A01

The application of analog signal conditioning to flight-test data-acquisition systems is discussed. Emphasis is placed on practical applications of signal conditioning for the most common flight-test data-acquisition systems. A limited amount of theoretical discussion is included to assist the reader in a more complete understanding of the subject matter. Nonspecific signal conditioning, such as amplification, filtering, and multiplexing, is discussed. Signal conditioning for various specific transducers and data terminal devices is also discussed to illustrate signal conditioning that is unique to particular types of transducers. The purpose is to delineate for the reader the various signal-conditioning technique options, together with tradeoff considerations, for commonly encountered flight-test situations.
Author

**N86-29817#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

### IMPROVING THE INTERPRETABILITY OF AN AIRCRAFT ATTITUDE INDICATOR M.S. Thesis

M. A. DIPADUA 1986 59 p
(AD-A166329; AFIT/CI/NR-86-27T) Avail: NTIS HC A04/MF A01 CSCL 01D

Two display types and four aircraft size ratios were investigated in this thesis to determine their effect on attitude display interpretability. The two display designs used were an outside-in (moving plane) and an inside-out (moving horizon) display. The four aircraft symbol lengths were measured relative to the size of the artificial horizon (33 percent, 50 percent, 67 percent, 100 percent). Twenty flight naive subjects were tested in two phases with both display types and all four size ratios. The first phase tested subjects' reaction to the sudden awareness of a change in attitude. The dependent variables measured, reaction time and error rate, indicated a preference for the outside-in display. The small size ratio was significantly better than the larger ones with reaction time as the dependent variable. A significant difference between sizes was not the case when the dependent variable error rate was measured. The second phase consisted of a dynamic flying task on an Apple PC computer. The dependent measures were the root mean square (RMS) error due to roll and the RMS error due to pitch. A significant difference in display types, favoring the outside-in type, was found with the RMS error due to roll as the dependent measure. No significant differences were found when the RMS error due to pitch was used as the dependent measure. Sizes did, however, approach significance in this case.
GRA

**N86-30728#** Aerojet Electrosystems Co., Azusa, Calif.

### DESIGN, DEVELOPMENT AND INTEGRATE/INSTALL AN AIRBORNE REMOTE INSTRUMENTATION SYSTEM (AIREYE) Final Report

J. J. BOMMARITO and L. E. SAYLOR Aug. 1985 79 p
(Contract DTCG23-80-C-20012)
(AD-A166755; REPT-7921; USCG-D-27-85) Avail: NTIS HC A05/MF A01 CSCL 01C

A prototype airborne remote instrument system, AIREYE, was developed for the U.S. Coast Guard by Aerojet ElectroSystems Company. This multisensor system permits real-time day/night, all weather detection, mapping and documentation of vessels and pollution at sea. The system was installed aboard a coast Guard Hu-25A Falcon fanjet aircraft and flight tested off the California coast. Surveillance data were obtained from natural oil seeps, known optical and radar targets, routine shipping and targets of opportunity. The AIREYE system consists of a sidelooking radar, infrared/ultraviolet line scanner, active gated television systems, aerial reconnaissance camera and a processor/display recording subsystem with real-time digital image enhancement capability. The system reliably detected and mapped oil seeps and vessel locations for environmental conditions ranging from dense undercast to clear, windspeeds from 0 to greater than 25 knots and from daytime to total darkness. The ability to read a vessel's name and determine deck activity in total darkness was demonstrated. The AIREYE real-time digital enhancement provided detection, recognition and identification of targets of interest when not otherwise possible with unenhanced imagery. Test results demonstrated that the AIREYE system will provide greatly enhanced capability in the U.S. Coast Guard missions of Marine Environmental Protection (MEP), Enforcement of Laws and Treaties and Search and Rescue.
Author (GRA)

**N86-30729#** Aeronautical Systems Div., Wright-Patterson AFB, Ohio.

### AIRBORNE NAVIGATION REMOTE MAP READER EVALUATION Final Report, 1 Sep. 1984 - 30 Sep. 1985

J. C. BYRD Mar. 1986 56 p
(AD-A166976; ASD-TR-86-5004) Avail: NTIS HC A04/MF A01 CSCL 01C

The U.S. Air Force evaluated the Full-Color Remote Map Reader built by Thomson-CSF of France under the Foreign Weapons, Equipment, and Technology Evaluation program. The unit is used in a military aircraft to provide a moving map video display for the aircrew. Map data is contained in a 65-foot roll of 35mm film at 11.4:1 reduction, which allows approximately 550 sq. ft. of aeronautical charts of any standard scale to be stored in one cassette. The unit moves the film with microprocessor-controlled servo motors and performs scanning, rotation and zoom with a microprocessor-controlled flying spot scanner. It obtains navigation data from the aircraft MIL-STD-1553 data bus and presents video on a full-color, shadow-mask cathode ray tube. The evaluation determined that the moving map display is useful in several Air Force missions, and that the French map reader technology is roughly equivalent to devices recently developed in the U.S.
Author (GRA)

# 07

# AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**A86-43910#**

**PROPELLING THE AEROSPACE PLANE**

Mechanical Engineering (ISSN 0025-6501), vol. 108, June 1986, p. 32-36.

Attention is given to the design features, prospective performance levels and technology development aspects of the combined turbojet/scramjet propulsion system currently undergoing conceptual definition for the hypersonic/transatmospheric 'aerospace plane'. The scramjet engine design under intensive consideration is able to operate as a conventional ramjet from speeds of Mach 3.5 to 6, and then as a true scramjet from Mach 5 to 12. Acceleration to Mach 3.5 would be accomplished by a separate complement of turbojet engines. Attention is given to the characteristics of liquid hydrogen fuel that render it an advantageous propellant for such powerplants. O.C.

**A86-43939#**

**INFLUENCE OF TURBINE-ENGINE DESIGN ON FLIGHT SAFETY [WPLYW KONSTRUKCJI SILNIKOW TURBINOWYCH NA BEZPIECZENSTWO LOTU]**

M. LAGOSZ and S. SZCZECINSKI (Wojskowa Akademia Techniczna, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Jan. 1986, p. 20-22. In Polish. refs

During the operation of aircraft turbine engines, failures sometimes occur which consist in the breaking off of single rotor blades or larger parts of the rotating components. The present paper attempts to determine how engine design features can affect the extent of damage to the engine and to the fuselage during failures of this type. B.J.

**A86-44005#**

**THE NEXT HOT FIGHTER ENGINE**

J. S. PETTY, R. J. HILL, A. C. PICCIRILLO, and A. E. FANNING (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 40-43.

The U.S. Air Force's projected Advanced Tactical Fighter (ATF) will be the first such vehicle to cruise over long distances at supersonic speeds, without afterburning and without compromise of subsonic range. The ATF's STOL and high maneuverability requirements have been judged to require nonaxisymmetric vectoring and reversing nozzles, contrarotating turbine spools, high throughflow compressors, and digital electronic engine controls without hydromechanical backups. Several variable geometry features are also under consideration in the two technology demonstration engines currently under development in order to furnish balanced subsonic vs supersonic operating efficiencies. O.C.

**A86-44007#**

**ROTARY GROWS UP**

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 48-51.

In conjunction with the use of composite airframes, a flightweight high power rotary engine of modest cost and gasoline or kerosene fuel rather than avgas operation could have a substantial impact on the general aviation market. Attention is presently given to the development status of engines of this type, and to configurational features they have incorporated; such features include stratified charge combustion, electronically controlled high pressure fuel injectors, friction-reduction coatings, and high temperature ceramics. specific fuel consumption ratings comparable to those of piston engines are already obtainable, with lower vibration. O.C.

**A86-44697**

**THE EFFECT OF DEPOSITS ON THE COOLING EFFICIENCY OF GAS-TURBINE ENGINE BLADES [VLIIANIE OTLOZHENII NA EFFEKTIVNOST' OKHLAZHDENIIA LOPATOK GAZOTURBINNYKH DVIGATELEI]**

S. Z. KOPELEV and V. G. DAMASKIN Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 8, no. 2, 1986, p. 71-73. In Russian.

A method is proposed for calculating the thermal and hydraulic characteristics of blades with deposits, and an expression relating the intensity of heat transfer from cooled blades to the thickness and thermophysical properties of the deposits is obtained. It is shown that the deposits formed on blades during service have a noticeable effect on the thermal state of the blades, which must be taken into account in designing blades and blade-cooling systems. V.L.

**A86-44872#**

**ROLE OF SHOCKS IN TRANSONIC/SUPERSONIC COMPRESSOR ROTOR FLUTTER**

O. O. BENDIKSEN (Princeton University, NJ) (International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings, p. 691-701) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1179-1186. Previously cited in issue 02, p. 110, Accession no. A86-11684. refs

**A86-44925#**

**AXISYMMETRIC THREE-DIMENSIONAL FLOW IN THE COOLED GAS TURBINE [ROTATIONSSYMMETRISCHE RAEUMLICHE STROEMUNG IN DER GERKUEHLTEN GASTURBINE]**

E. RIKLI Zuerich, Eidgenoessische Technische Hochschule, Doktor der technischen Wissenschaften Dissertation, 1984, 121 p. In German. refs

The present investigation is concerned with a computational procedure for the cooled gas turbine, taking into account the determination of state variables, velocities, and the location of the meridian streamlines. This procedure makes it possible to calculate two-dimensional flow characteristics in an effective channel. The mass flow along the path of expansion is kept variable, corresponding to the introduction of cooling air. Attention is given to a geometrical description of the meridian channel, a one-dimensional solution, the stream function in a variable mass flow, the cooling air distribution function, changes of state in the two-dimensional case, a description of the streamlines, the initial solution for the meridian streamline characteristics, the equations of motion, a local coordinate system, the solution of the equilibrium condition in a control surface, a two-dimensional solution, and selected results. G.R.

**A86-45375#**

**DEVELOPMENT OF IN-FLIGHT THRUST MEASUREMENT PROCEDURES FOR AN AFTERBURNING TURBOFAN ENGINE**

E. C. ROONEY and C. E. WILT (U.S. Navy, Naval Air Systems Command, Washington, DC) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-11, 1985. 12 p. Navy-sponsored research. refs

(AIAA PAPER 85-1405)

This paper presents a historical perspective of the development of in-flight thrust measurement procedures for a mixed-flow afterburning turbofan engine. Portions of this program were previously extracted for use in the examples used in SAE AIR-1703: 'In-Flight Thrust Determination'. The purpose of the in-flight thrust measurement program was to provide for economical definition of performance characteristics over a range of subsonic, transonic and supersonic flight conditions. Development of the in-flight thrust measurement procedures is discussed from the planning through flight phases, including: contract provisions, methodology, instrumentation, engine test cell program, thrust-drag accounting and flight validation. The initial flight results showed evidence of bias errors. Investigation of these errors ultimately led tto development of alternative in-flight thrust methodology. Author

**A86-45504*#** United Technologies Corp., Windsor Locks, Conn.
**PROPELLER NOISE CAUSED BY BLADE TIP RADIAL FORCES**
D. B. HANSON (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. Research supported by United Technologies Corp. refs
(Contract NAS3-23720; NAS3-23051)
(AIAA PAPER 86-1892)

New experimental evidence which indicates the presence of leading edge and tip edge vortex flow on Prop-Fans is examined, and performance and noise consequences are addressed. It was shown that the tip edge vortex is a significant noise source, particularly for unswept Prop-Fan blades. Preliminary calculations revealed that the addition of the tip side edge source to single rotation Prop-Fans during take off conditions improved the agreement between experiment and theory at blade passing frequency. At high-speed conditions such as the Prop-Fan cruise point, the tip loading effect tends to cancel thickness noise. K.k.

**A86-45819**
**MECHANICAL DESIGN OF GAS TURBINE BLADING IN CAST SUPERALLOYS**
A. G. DODD (Rolls-Royce, Ltd., Derby, England) (Institute of Metals, Conference on Casting of Superalloys, London, England, Feb. 27, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, May 1986, p. 476-485. refs

The mechanical design of hot turbine blading has two main phases: (1) optimization, which yields the choice of material, number of blades, and general configuration, and (2) detailed design of the particular features of the blades. The first phase makes use of the data available, which are usually limited, to provide an outline mechanical assessment of commercial viability. At this stage maximization of the lifetime to failure is considered in terms of the temperature and stress at each radial position. In the second phase, failure modes are considered in more detail. The methods used in both stages are discussed, with emphasis on material and manufacture, taking as an example the blading in civil aircraft gas turbines. Particular attention is paid to the problems of designing with single-crystal cast superalloys. Author

**A86-46024#**
**EXPERIMENTAL STUDY OF FLIGHT EFFECT ON FAN NOISE. I - A STUDY OF INFLOW CONTROL DEVICE FOR SIMULATING IN-FLIGHT FAN NOISE IN STATIC TEST**
H. KOBAYASHI and T. TORISAKI (National Aerospace Laboratory, Chofu, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, May 1986, p. 1536-1543. Research supported by the Agency of Industrial Science and Technology. refs

The design, development, and performance of an inflow control device (ICD) which permits (by reducing turbulence) the static-test simulation of flight test conditions when investigating the fan noise of turbofan aircraft engines are reported. Experimental tests on various candidate materials for ana ICD are described along with measurements of the inflow turbulence in flight-test conditions. A prototype 4-m-diameter hemispheric ICD constructed with a combination of perforated plate, wire screen, and 6.3-mm-core aspect-ratio-8 honeycomb is found to reduce the inflow turbulence level to 1 percent at flow velocity 2-5 m/s while lowering acoustic transmission by only 1.0 dB or less. T.K.

**N86-29818*#** Oklahoma Univ., Norman.
**TRANSMISSION LINE DESIGN FOR A POWER DISTRIBUTION SYSTEM AT 20 KHZ FOR AIRCRAFT**
L. W. ZELBY, J. B. MATHES, and J. W. SHAWVER Washington NASA Jul. 1986 38 p
(Contract NAG3-508)
(NASA-CR-3987; NAS 1.26:2987) Avail: NTIS HC A03/MF A01 CSCL 21E

A low inductance, low characteristic impedance transmission line was designed for a 20 kHz power distribution system. Several different conductor configurations were considered: strip lines, interdigitated metal ribbons, and standard insulated wires in multiwire configurations (circular and rectangular cylindrical arrangements). The final design was a rectangular arrangement of multiple wires of the same gauge with alternating polarities from wire to wire. This offered the lowest inductance per unit length (on the order of several nanohenries/meter) and the lowest characteristic impedance (on the order of one Ohm). Standard multipin connectors with gold-plated elements were recommended with this transmission line, the junction boxes to be internally connected with flat metal ribbons for low inductance, and the line to be constructed in sections of suitable length. Computer programs for the calculation of inductance of multiwire lines and of capacitances of strip lines were developed. Author

**N86-29819*#** Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
**MULTI-VARIABLE CONTROL OF THE GE T700 ENGINE USING THE LQG/LTR DESIGN METHODOLOGY**
W. H. PFEIL (General Electric Co., Lynn, Mass.), M. ATHANS, and H. A. SPANG, III (General Electric Co., Schenectady, N. Y.) Apr. 1986 16 p
(Contract NAG2-297)
(NASA-CR-177080; NAS 1.26:177080; LIDS-P-1547) Avail: NTIS HC A02/MF A01 CSCL 21E

The design of scalar and multi-variable feedback control systems for the GET700 turboshaft engine coupled to a helicopter rotor system is examined. A series of linearized models are presented and analyzed. Robustness and performance specifications are posed in the frequency domain. The linear-quadratic-Gaussian with loop-transfer-recovery (LQG/LTR) methodology is used to obtain a sequence of three feedback designs. Even in the single-input/single-output case, comparison of the current control system with that derived from the LQG/LTR approach shows significant performance improvement. The multi-variable designs, evaluated using linear and nonlinear simulations, show even more potential for performance improvement. Author

**N86-29820*#** Wu (Jiunn-Jenq), Sierra Madre, Calif.
**EXPERIMENTS ON HIGH SPEED EJECTORS**
J. J. WU Jul. 1986 82 p
(Contract NASA ORDER A40174-C; F49620-81-C-0043)
(NASA-CR-177419; NAS 1.26:177419) Avail: NTIS HC A05/MF A01 CSCL 21E

Experimental studies were conducted to investigate the flow and the performance of thrust augmenting ejectors for flight Mach numbers in the range of 0.5 to 0.8, primary air stagnation pressures up to 107 psig (738 kPa), and primary air stagnation temperatures up to 1250 F (677 C). The experiment verified the existence of the second solution ejector flow, where the flow after complete mixing is supersonic. Thrust augmentation in excess of 1.2 was demonstrated for both hot and cold primary jets. The experimental ejector performed better than the corresponding theoretical optimal first solution ejector, where the mixed flow is subsonic. Further studies are required to realize the full potential of the second solution ejector. The research program was started by the Flight Dynamics Research Corporation (FDRC) to investigate the characteristic of a high speed ejector which augments thrust of a jet at high flight speeds. Author

**N86-29822#** Department of the Air Force, Washington, D.C.
**SELF-RETAINED PLATFORM COOLING PLATE FOR TURBINE VANE Patent Application**
S. N. FINGER, inventor (to Air Force) 13 Nov. 1985 13 p
(AD-D012218; US-PATENT-APPL-SN-797581) Avail: NTIS HC A02/MF A01 CSCL 21E

A turbine stator vane assembly for gas turbine or turbojet engines has an improved structure for retention of a cooling impingement plate. Two inwardly directed flanges are added to the wall-like extensions extending from the bottom of the platform upon which the vane is mounted. The cooling impingment plate is resiliently snapped into place between pin fins on the bottom of the platform and the flanges. Author (GRA)

**N86-30664#** Liege Univ. (Belgium).
**DYNAMIC ANALYSIS OF STRUCTURES WITH FLEXIBLE ROTORS**
M. GERADIN and N. KILL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 477-485 1985
Avail: NTIS HC A99/MF E03

Analytical tools for the dynamic structural analysis of machines with rotating parts such as aircraft engines are described. The finite element analysis is used for discretization, and the rotating parts are described using a 3-D formalism which includes in the kinetic energy expression the gyroscopic effects induced by the local changes of angular velocity produced by the deformation. The implementation of the formalism is specialized to the modeling of flexible rotors made of shafts and disks typical of modern aircraft engines. The effectiveness of the component mode synthesis method to reduce the size of the system of equations is demonstrated in the case of systems made of rotating and fixed parts. Critical speed and stability analyses and unbalance response calculations are performed by a sweeping procedure. The concepts are applied to the dynamic analysis of a high by-pass ratio aircraft engine. ESA

**N86-30730*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
**UNSTEADY DESIGN-POINT FLOW PHENOMENA IN TRANSONIC COMPRESSORS Final Report**
J. B. GERTZ and A. H. EPSTEIN Aug. 1986 210 p
(Contract NGL-22-009-383)
(NASA-CR-176879; NAS 1.26:176879) Avail: NTIS HC A10/MF A01 CSCL 21E

High-frequency response probes which had previously been used exclusively in the MIT Blowndown Facility were successfully employed in two conventional steady state axial flow compressor facilities to investigate the unsteady flowfields of highly loaded transonic compressors at design point operation. Laser anemometry measurements taken simultaneously with the high response data were also analyzed. The time averaged high response data of static and total pressure agreed quite well with the conventional steady state instrumentation except for flow angle which showed a large spread in values at all radii regardless of the type of instrumentation used. In addition, the time resolved measurements confirmed earlier test results obtained in the MIT Blowdown Facility for the same compressor. The results of these tests have further revealed that the flowfields of highly loaded transonic compressors are heavily influenced by unsteady flow phenomena. The high response measurements exhibited large variations in the blade to blade flow and in the blade passage flow. The observed unsteadiness in the blade wakes is explained in terms of the rotor blades' shed vorticity in periodic vortex streets. The wakes were modeled as two-dimensional vortex streets with finite size cores. The model fit the data quite well as it was able to reproduce the average wake shape and bi-modal probability density distributions seen in the laser anemometry data. The presence of vortex streets in the blade wakes also explains the large blade to blade fluctuations seen by the high response probes which is simply due to the intermittent sampling of the vortex street as it is swept past a stationary probe. Author

**N86-30731*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Mechanical Engineering.
**THERMODYNAMIC EVALUATION OF TRANSONIC COMPRESSOR ROTORS USING THE FINITE VOLUME APPROACH Status Report**
S. NICHOLSON and J. MOORE Aug. 1986 292 p
(Contract NAG3-593)
(NASA-CR-176947; NAS 1.26:176947; JM/86-6) Avail: NTIS HC A13/MF A01 CSCL 21E

A method was developed which calculates two-dimensional, transonic, viscous flow in ducts. The finite volume, time marching formulation is used to obtain steady flow solutions of the Reynolds-averaged form of the Navier Stokes equations. The entire calculation is performed in the physical domain. The method is currently limited to the calculation of attached flows. The features of the current method can be summarized as follows. Control volumes are chosen so that smoothing of flow properties, typically required for stability, is now needed. Different time steps are used in the different governing equations to improve the convergence speed of the viscous calculations. A new pressure interpolation scheme is introduced which improves the shock capturing ability of the method. A multi-volume method for pressure changes in the boundary layer allows calculations which use very long and thin control volumes. A special discretization technique is also used to stabilize these calculations. A special formulation of the energy equation is used to provide improved transient behavior of solutions which use the full energy equation. The method is then compared with a wide variety of test cases. The freestream Mach numbers range from 0.075 to 2.8 in the calculations. Transonic viscous flow in a converging diverging nozzle is calculated with the method; the Mach number upstream of the shock is approximately 1.25. The agreement between the calculated and measured shock strength and total pressure losses is good. Essentially incompressible turbulent boundary layer flow in a adverse pressure gradient is calculated and the computed distribution of mean velocity and shear stress are in good agreement with the measurements. At the other end of the Mach number range, a flat plate turbulent boundary layer with a freestream Mach number of 2.8 is calculated using the full energy equation; the computed total temperature distribution and recovery factor agree well with the measurements when a variable Prandtl number is used through the boundary layer. Author

**N86-30732*#** Systems Control Technology, Inc., Palo Alto, Calif.
**ROBUST DETECTION, ISOLATION AND ACCOMMODATION FOR SENSOR FAILURES Final Report**
A. EMAMI-NAEINI, M. M. AKHTER, and S. M. ROCK Jul. 1986 164 p
(Contract NAS3-24079)
(NASA-CR-174825; NAS 1.26:174825; SCT-85-5449) Avail: NTIS HC A08/MF A01 CSCL 21E

The objective is to extend the recent advances in robust control system design of multivariable systems to sensor failure detection, isolation, and accommodation (DIA), and estimator design. This effort provides analysis tools to quantify the trade-off between performance robustness and DIA sensitivity, which are to be used to achieve higher levels of performance robustness for given levels of DIA sensitivity. An innovations-based DIA scheme is used. Estimators, which depend upon a model of the process and process inputs and outputs, are used to generate these innovations. Thresholds used to determine failure detection are computed based on bounds on modeling errors, noise properties, and the class of failures. The applicability of the newly developed tools are demonstrated on a multivariable aircraft turbojet engine example. A new concept call the threshold selector was developed. It represents a significant and innovative tool for the analysis and synthesis of DIA algorithms. The estimators were made robust by introduction of an internal model and by frequency shaping. The internal mode provides asymptotically unbiased filter estimates.The incorporation of frequency shaping of the Linear Quadratic Gaussian cost functional modifies the estimator design to make it suitable for sensor failure DIA. The results are compared with previous studies which used thresholds that were selcted empirically. Comparison of these two techniques on a nonlinear dynamic engine simulation shows improved performance of the new method compared to previous techniques Author

**N86-30733*#** Detroit Diesel Allison, Indianapolis, Ind.
**FEASIBILITY STUDY FOR CONVERTIBLE ENGINE TORQUE CONVERTER**
Oct. 1985 72 p
(Contract NAS3-24092)
(NASA-CR-175082; NAS 1.26:175082; EDR-12118) Avail: NTIS HC A04/MF A01 CSCL 21E

The feasibility study has shown that a dump/fill type torque converter has excellent potential for the convertible fan/shaft engine. The torque converter space requirement permits internal housing within the normal flow path of a turbofan engine at acceptable engine weight. The unit permits operating the engine in the turboshaft mode by decoupling the fan. To convert to turbofan mode, the torque converter overdrive capability bring the fan speed up to the power turbine speed to permit engagement of a mechanical lockup device when the shaft speed are synchronized. The conversion to turbofan mode can be made without drop of power turbine speed in less than 10 sec. Total thrust delivered to the aircraft by the proprotor, fan, and engine during tansient can be controlled to prevent loss of air speed or altitude. Heat rejection to the oil is low, and additional oil cooling capacity is not required. The turbofan engine aerodynamic design is basically uncompromised by convertibility and allows proper fan design for quiet and efficient cruise operation. Although the results of the feasibility study are exceedingly encouraging, it must be noted that they are based on extrapolation of limited existing data on torque converters. A component test program with three trial torque converter designs and concurrent computer modeling for fluid flow, stress, and dynamics, updated with test results from each unit, is recommended. Author

**N86-30734#** Exotech, Inc., Campbell, Calif.

**TIME RESOLVED AND TIME AVERAGED FLOW EVALUATION FOR AN ISOLATED TRANSONIC COMPRESSOR ROTOR Final Report**

F. NEUHOFF Mar. 1986 61 p
(Contract N00014-84-C-0766)
(AD-A166759; TR-8601) Avail: NTIS HC A04/MF A01 CSCL 20D

A 0.28-m single stage transonic fan was operated in a rotor only configuration. Overall performance was measured and radial distributions of inlet and outlet velocity were obtained using time-averaging combination temperature-pneumatic probes. These results were compared to the prediction of a finite element computer code (TURBOFEM) prediction. The blade-to-blade velocity and pressure distributions were measured using the Dual Probe Digital Sampling technique (involving two commercial semi-conductor probes of simple design). Data were obtained from hub-to-tip at both near-sonic and at supersonic inlet relative Mach numbers. The rotor losses were derived as blade-to-blade distributions and the shock losses were evaluated as components of the total loss at each radius. Based on the limited data obtained near sonic conditions, a combination of the profile loss model of Koch & Smith and shock loss model of Dunker was found to predict the measured radial loss distribution quite well. Preliminary observations of rotor shock oscillations were also reported. Compressor rotors, Compressor stators, Transonic flow, Turbomachinery flow fields, Transonic loss measurements, and Finite element codes. GRA

**N86-30735#** Doellner (O. Leonard), Tucson, Ariz.

**JET-ENGINE COMBUSTOR SPECTRAL RADIATION MEASUREMENTS USING FIBEROPTIC INSTRUMENTATION SYSTEM. RADIANT ENERGY POWER SOURCE FOR JET AIRCRAFT Final Report**

O. L. DOELLNER Feb. 1986 121 p
(Contract DE-FG01-82CE-15144)
(DE86-007289; DOE/CE-15144/T2) Avail: NTIS HC A06/MF A01

This report is a summary of spectral radiation measurements made at Williams Air Force Base, Chandler, Arizona on a General Electric J-85-5 engine. The spectral radiation measurements consisted of a complete axial profile down the combustor and are directed toward the application of Radiant Energy Power Source for Jet Aircraft. Radiant Energy Power Source for Jet Aircraft relates to the use of photovoltaic cells to generate the electrical power demands of the aircraft. The photovoltaic cells are mounted inside the casing of the jet engine, are thermally insulated from the normally hot engine casing, and are appropriately cooled. The photovoltaic cells receive their required radiant energy from the combustion flame by holes in the combustion liner. The instrumentation system used to make these measurements employed fiberoptic probes - entering the engine by way of an existing (modified) access plate - to obtain the radiation measurements. Such an instrumentation system has the strong advantage of being able to measure radiation from all the holes running axially down the combustor without making any holes in the plenum/engine casing - as would be necessary if sapphire observation windows were used. DOE

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A86-43497#**

**CONTROLLABILITY OF REDUNDANT FLIGHT CONTROL SYSTEM AND PRESSURE EQUALIZATION OF REDUNDANT SERVO ACTUATORS**

S. GUO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 71-79. In Chinese, with abstract in English.

A study on the control behavior of a redundant flight control system is carried out. The controllability of the redundant system and the effects of bias on the dynamic response of the controllable and uncontrollable state variables is stressed. The conclusions are extended to the pressure equalization problem of redundant servo actuators. Then a type of proportional plus integral digital equalization loop is designed. The good behavior of equalization is verified through experiments. Author

**A86-43498#**

**DESIGN AND RESEARCH OF AIRCRAFT PARAMETER-ADAPTIVE LATERAL COMMAND AUGMENTATION SYSTEMS**

S. XIAO and W. ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 80-90. In Chinese, with abstract in English.

A scheme of parameter-adaptive command augmentation system (CAS) is designed for a supersonic-jet's lateral motions. Its digital simulation is also investigated. The purpose of the work is to provide the aircraft with superior handling qualities against rapid variation of the aircraft's lateral parameters and effect of external disturbances. The behavior of CAS during constant altitude-coordination both at constant and decreasing speed, as well as under stochastic side-gust disturbances is addressed. The time responses of the aircraft with CAS are compared with those of the free aircraft under the above conditions. It is shown that the version of the adaptive CAS is superior in anti-disturbance and adaptability to time-varying parameters. The microcomputer implementation of the parameter-adaptive lateral CAS and the choice of the microcomputer are also considered. Author

**A86-43536#**

**AN ADAPTIVE FLIGHT CONTROL SYSTEM DESIGN FOR CCV WITH AN UNKNOWN INTERACTOR MATRIX**

K. KANAI and S. UCHIKADO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, April 1986, p. 211-221. In Japanese, with abstract in English. refs

A design method for a Control Configured Vehicle adaptive flight control system with an unknown interactor matrix is proposed whose matrix is uniquely constructed from a controlled system and helps determine the control law. The system is applied to the case of small-sized and high speed aircraft with vertical canard and flap control surfaces, and its effectiveness is demonstrated by a numerical simulation. R.R.

**A86-44932**

**AIRCRAFT FLUTTER ANALYSIS (THE FOURTH JOHN WESTON MEMORIAL LECTURE)**

A. J. VERMEULEN (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) Aeronautica Meridiana (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 1-12.

A comprehensive account is given of current methods for the study and analysis of flutter in aircraft structures, with particular reference to such high performance aircraft cases as the oscillation of a fighter wing with wingtip missiles. After a development history of flutter analysis and design methods, attention is given to analytical techniques, ground vibration testing, unsteady aerodynamics, the solution of the flutter equation, and the wind tunnel testing of dynamically similar models. O.C.

**A86-44944**

**NAVY DEPARTURE/SPIN AND AIR COMBAT MANEUVERING EVALUATION OF A NATIONAL AERONAUTICS AND SPACE ADMINISTRATION DEVELOPED FLIGHT CONTROL SYSTEM FOR THE F-14**

C. M. BAUCOM and C. CLARK (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 162-177.

An account is given of work done under a program involving NASA, Grumman Aerospace Corp., and the Navy, intended to design a system that would prevent spins without compromising the tactical maneuvering capability of the F-14. (As currently flown by the operational Navy) the F-14 exhibits two extremely undesirable flying qualities characteristics in the high angle-of-attack flight regime. First, lateral control surface deflections at high AOA can induce departure which may progress into an unrecoverable flat spin if recovery control inputs are delayed. Second, basic flying qualities are significantly degraded (typically by wing rock and lateral control reversal) at high AOA, thus increasing pilot workload in the tactical environment. An automatic-rudder interconnect (ARI) system was developed and enhanced with a low speed/high AOA cross control capability. Topics covered include: test airplane description; external store configurations; test site; simulation support of the flight test effort; and flight tests. The ARI concepts provided significantly improved high AOA flying qualities characteristics for the F-14. No serious degradation to the departure/spin resistance characteristics resulted. The low speed/high AOA cross control modification was successfully integrated into the flight control system; this option permitted the pilot to override the differential stabilator limiting and the lateral-stick-to-rudder-interconnect features, thus retaining the gross lateral control capability that currently exists in the production F-14. Future plans for further development of the ARI are noted. D.H.

**A86-44946**

**A320 FLIGHT CONTROLS**

S. G. CORPS (Airbus Industrie, Toulouse, France) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 196-210.

The A320 widebody twin aircraft is discussed with emphasis on the flight controls. The A320 is the successor to the A300 and A310, which employed a number of new technologies. The new aircraft will use the fly-by-wire technology proven on the A310 and on Concorde, with a type of controller permitting the aircraft to survive a short term total electrical failure by manually changing the flight path if necessary. (Probability of needing such a fly-by-wire failure mode is less than one in a billion per hour; Concorde has full mechanical reversion which has never had to be used). Side stick control will be used rather than center stick. The fly-by-wire architecture is to be developed by Aerospatiale (the French partner of Airbus Industrie). Control in pitch, envelope protection (overspeed), stall protection, windshear protection, maneuver protection, attitude protection, control in roll, and yaw control are discussed. In connection with side stick operation, side stick coupling, the training situation, the take-over situation and system redundancy are covered. Counting options to buy, as of August 1985 (18 months before the first flight), the order book stood at about 200 aircraft. D.H.

**A86-45058#**

**PRELIMINARY DESIGN OF LOW AUTHORITY SAS. II**

T. HACKER (Institute of Aviation, Bucharest, Rumania) and B. TEODORESCU (Bucuresti, Institutul Politehnic, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 31, Jan.-Feb. 1986, p. 3-12. refs

The region of admissible feedback gains is constructed for the Dutch roll mode. The time constant of the washout filter in the rudder loop is chosen as a tradeoff between response time and the interaction of the washout mode with fast lateral-directional air-frame modes. Perturbation methods are shown to provide the theoretical background to model simplification and to enable the assessment of the validity of simplified models. Author

**A86-45144**

**NUMERICAL MODELLING OF THE DYNAMICS OF AEROBATIC MANOEUVRES**

Z. DZYGADLO and R. BOLDAK Journal of Technical Physics (ISSN 0324-8313), vol. 26, no. 2, 1985, p. 225-245. refs

A method for calculating the plane and spatial aerobatic maneuvers of an aircraft assumed to be a rigid body, its control systems being displaceable but rigid, is discussed. The equations of motion constitute a complete, nonlinear set in a reference frame connected with the aircraft. The laws of control assume the aerodynamic characteristics and the data set for the TS-11 Iskra jet trainer. Numerical results are reported on the dynamics of an aircraft performing a loop or a roll; these results permit the influence of motion and control parameters on the behavior of the aircraft during these maneuvers to be determined. C.D.

**A86-45748#**

**THE DYNAMICS OF LIMITING HELICOPTER MANEUVERS AT A VERY LOW ALTITUDE [DYNAMIKA GRANICZNYCH MANEWROW SMIGLOWCA W LOTACH NISKICH]**

K. SZUMANSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 102, 1985, p. 3-38. In Polish. refs

The problems under consideration are those of a helicopter flying in the proximity of the ground including hovering, load lifting, and rescue operations, hedgehopping flights (during agricultural work, for instance) and the phases of flight near the ground (takeoff and landing). Helicopter maneuvers under normal conditions and in the case of a power system failure are analyzed. The limits of the possibility of performing such maneuvers are estimated assuming that full use is made of the functional and structural properties of the system composed of the aircraft and the pilot. Author

**A86-46002*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**CONTROL OF V/STOL AIRCRAFT**

J. A. FRANKLIN (NASA, Ames Research Center, Moffett Field, CA) Aeronautical Journal (ISSN 0001-9240), vol. 90, May 1986, p. 157-173. refs

This paper deals with control of V/STOL aircraft in powered-lift flight. A review of representative operational mission tasks is presented for the take-off, transition, hover and landing flight phases. Characteristics inherent in the basic airframe and propulsion system and the behavior associated with control augmentation systems are considered. Demands for augmented stability and control response to meet certain mission operational requirements are discussed. Experience from ground-based simulation and flight experiments that illustrates the impact of augmented stability and control on aircraft design is related by example. Author

**A86-46173#**

**A SIMULATION OF AN INTEGRATED FLIGHT CONTROL/AIR-GROUND CANNON FIRING SYSTEM [SIMULATION D'UN SYSTEME INTEGRE DE COMMANDES DE VOL ET DE CONDUITE DE TIR CANON AIR-SOL]**

B. DANG VU and C. LA BURTHE (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium on Improvement of Combat Performance for Existing and Future Aircraft, Treviso, Italy, Apr. 14-18, 1986) ONERA, TP, no. 1986-31, 1986, 15 p. In French. refs

(ONERA, TP NO. 1986-31)

Results are reported on an ONERA study of an integrated flight and fire control system (IFFC) for modern attack aircraft. The IFFC was developed to furnish flight stability in the ground attack phase and to maximize the success of an air-ground strafing run. Maximizing the performance of the maneuver depended on integrating the pilot in the loop while minimizing the pilot workload. The pilot selected a target which the on-board computer maintained on a cockpit display while aiming the cannon, i.e., the aircraft. Target tracking therefore activated the control laws for guiding the aircraft toward the target. In the simulation, statistics were kept on the success of the firing and the success at maintaining a flight path to the target. The IFFC was effective at both guidance and workload alleviation tasks, and was compact enough for incorporation in current flight control and guidance computer systems. M.S.K.

**A86-46367#**

**AN ANALYSIS OF THE MOTION OF AN AIRCRAFT ON THE GROUND [ANALIZA RUCHU SAMOLOTU NA ZIEMI]**

A. WOJNAROWSKI and W. KOWALSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 103, 1985, p. 3-20. In Polish. refs

The method and the results of an analysis of the control problem of an aircraft in its motion on the ground are presented. It is assumed that the aircraft performs a translational motion along the runway and angular oscillation, forced by the control system, about the center of gravity. Two methods of analysis are suggested: a simplified operational method for a system with a single degree of freedom and a more universal numerical method, on the basis of which the characteristics of motion of the aircraft for a two-degree-of-freedom system have been determined. The computation methods make it possible to characterize in an accurate manner the motion of the aircraft and to select the optimum excitation range, which is a condition for correct design of the ground steering system. Author

**A86-46368#**

**VIBRATION ANALYSIS OF A HELICOPTER FUSELAGE BY MEANS OF MATHEMATICAL MODELS [ANALIZA DRGAN KADLUBA SMIGLOWCA PRZY UZYCIU MODELI MATEMATYCZNYCH]**

J. STANISLAWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 103, 1985, p. 21-35. In Polish.

A simplified mathematical model of a helicopter in flight is described and used to determine the natural frequencies and modes of the fuselage. The problem of forced vibrations is studied by introducing into the model the external loads originating from the main rotor, the tail rotor, and the vibration damping element. Author

**A86-46453#**

**DISTURBANCE ATTENUATION BY A FREQUENCY-SHAPED LINEAR-QUADRATIC-REGULATOR METHOD**

H. IMAI (Setsunan University, Osaka, Japan), N. ABE (Mitsubishi Heavy Industry Co., Ltd., Nagoya, Japan), and M. KOBAYAKAWA (Kyoto University, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 397-402. refs

The problem of designing a control system such that the effect of disturbances can be attenuated while the stability of the closed-loop system is assured are considered. It is shown that a linear-quadratic regulator method with frequency-dependent weighting matrices can be effectively applied to this problem. Some inequalities that connect those weighting matrices to the return-difference matrix of a feedback control system are derived. Using these inequalities, the minimum singular value of the return-difference matrix of a feedback control system can be designed quite easily. C.D.

**A86-46454#**

**A DISCRETE-TIME MULTIVARIABLE MODEL-FOLLOWING METHOD APPLIED TO DECOUPLED FLIGHT CONTROL**

K. KANAI (Defense Academy, Yokosuka, Japan), P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada), and N. HORI Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 403-407. refs

(AIAA PAPER 85-1978)

The discrete-time version of the multivariable model-following control method, previously presented by the authors of this paper, is described. The modification of the control law that enables the control vector to be calculated at each instant using the past state vectors is also presented for synchronizing the change in the control input with the sampling instant. An alternative method of control is developed for a system whose high-frequency gain matrix is singular. This design requires a lower-order increase in the controller and makes the selection of the reference model easier than the method previously proposed by the authors. As an example, the design of the control system is given for flight control of an aircraft that has control-configured vehicle capabilities. The simulation study is carried out for a hypothetical T-2-CCV aircraft, with particular reference to a longitudinal mode. Author

**A86-46456#**

**UNFOLDING OF DEGENERATE HOPF BIFURCATION FOR SUPERSONIC FLOW PAST A PITCHING WEDGE**

N. SRI NAMACHCHIVAYA (Illinois, University, Urbana) and H. J. VAN ROESSEL (Western Ontario, University, London, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 9, July-Aug. 1986, p. 413-418. refs

This paper investigates the stability and bifurcation behavior of a double-wedge aerofoil performing a pitching motion at high angles of attack. When a pair of complex conjugate eigenvalues crosses the imaginary axis of the eigenvalue plane, the trivial solution loses stability giving rise to a periodic solution, known as Hopf bifurcation, provided certain transversality conditions are not violated. The existence of degenerate Hopf bifurcation due to the violation of Hopf's transversality condition at certain critical values of the system parameters is shown. The behavior of the pitching motion near these critical values is examined by unfolding the degeneracies. For the supersonic double-wedge aerofoil, various parameters defining the bifurcation paths were numerically evaluated. Author

**A86-46459*#** California Univ., Davis.

**IDENTIFICATION OF PILOT-VEHICLE DYNAMICS FROM IN-FLIGHT TRACKING DATA**

R. A. HESS (California, University, Davis) and M. A. MNICH (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 554-563) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 433-440. NASA-supported research. Previously cited in issue 22, p. 3230, Accession no. A85-45935. refs

**A86-46460*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**DEVELOPMENT OF CONTROL LAWS FOR A FLIGHT TEST MANEUVER AUTOPILOT**

G. S. ALAG and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 105-110) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 441-445. Previously cited in issue 22, p. 3229, Accession no. A85-45888. refs

**A86-46469#**

**COMPARISON OF ANGULAR AND METRIC GUIDANCE LAWS FOR TACTICAL MISSILES**

J.-L. DURIEUX (Cabinet d'Etudes Techniques d'Automatisation, Angouleme, France) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 505-507. refs

An angular guidance law for tactical missiles optimized by the adjoint technique is compared with a metric law for such missiles comprising an estimator connected to a terminal controller forcing the estimated miss distance to zero. The terms of comparison are miss distance and realizability. An analytic solution is given for one specific, significant case. It is concluded that linear-quadratic Gaussian optimization, without constraint on commanded acceleration and with stationary measurement and process noise, yields the same theoretical minimum miss distance irrespective of whether the control law is angular or metric. If an approximate angular law is used, the resulting performance degradation is inversely proportional to measurement noise. The metric law produces a performance advantage as a result of time-to-go measurement, which produces a better missile lateral acceleration history against a maneuvering target. C.D.

**A86-46716**

**PILOTING OF UNMANNED AIR VEHICLES**

R. E. CLAPP (Boeing Military Airplane Co., Wichita, KS) IN: Applications of artificial intelligence II; Proceedings of the Meeting, Arlington, VA, April 9-11, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 227-232. refs

While computer-controlled and piloted preplanned missions can be accomplished by autonomous air vehicles, such systems lack the flexibility with which to respond to contemporary battlefield conditions. Attention is presently given to the results of incorporating remote piloting capabilities predicated on vehicle sensor telemetry to ground stations. The relationships of a displayed scene to vehicle altitude, sensor focal length and display scale (magnification) are illustrated. O.C.

**N86-29863*#** Stanford Univ., Calif. Guidance and Control Lab.

**THE DESIGN OF MULTIRATE DIGITAL CONTROL SYSTEMS Final Report**

M. C. BERG Mar. 1986 217 p
(Contract NSG-4002)
(NASA-CR-177126; NAS 1.26:177126; SU-SUDAAR-553) Avail: NTIS HC A10/MF A01 CSCL 01C

The successive loop closures synthesis method is the only method for multirate (MR) synthesis in common use. A new method for MR synthesis is introduced which requires a gradient-search solution to a constrained optimization problem. Some advantages of this method are that the control laws for all control loops are synthesized simultaneously, taking full advantage of all cross-coupling effects, and that simple, low-order compensator structures are easily accomodated. The algorithm and associated computer program for solving the constrained optimization problem are described. The successive loop closures , optimal control, and constrained optimization synthesis methods are applied to two example design problems. A series of compensator pairs are synthesized for each example problem. The succesive loop closure, optimal control, and constrained optimization synthesis methods are compared, in the context of the two design problems. Author

**N86-29864*#** Kansas Univ., Lawrence. Dept. of Aerospace Engineering.

**AN INVESTIGATION OF EMPENNAGE BUFFETING Status Report, 15 Sep. 1985 - 15 Jan. 1986**

C. E. LAN and I. G. LEE 28 Jan. 1986 50 p
(Contract NAG2-371)
(NASA-CR-176973; NAS 1.26:176973) Avail: NTIS HC A03/MF A01 CSCL 01C

Progress in the investigation of empennage buffeting in reviewed. In summary, the following tasks were accomplished: relevant literatures was reviewed; equations for calculating structural response were formulated; root-mean-square values of root bending moment for a 65-degree rigid delta wing were calculated and compared with data; and a water-tunnel test program for an F-18 model was completed. Author

**N86-29865*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**FLIGHT DETERMINATION OF THE AERODYNAMIC STABILITY AND CONTROL CHARACTERISTICS OF THE NASA SGS 1-36 SAILPLANE IN THE CONVENTIONAL AND DEEP STALL ANGLES-OF-ATTACK OF BETWEEN -5 AND 75 DEGREES Final Report**

F. A. MAHDAVI and D. R. SANDLIN 1 Jun. 1984 110 p
(Contract NCC4-1)
(NASA-CR-176962; NAS 1.26:176962) Avail: NTIS HC A06/MF A01 CSCL 01C

The flight test procedure and the preliminary analysis of the results obtained from twenty manned flights of the SGS 1-36 in the high angles of attack Deep Stall region are discussed. A comparison of the flight determined stability and control derivatives, those of the wind tunnel, and the estimated aerodynamic data is also presented. Furthermore, deep stall dynamics response of the SGS 1-36 is discussed briefly to explain some of the unexpected flight observations. Author

**N86-29866*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EXPERIENCE WITH SYNCHRONOUS AND ASYNCHRONOUS DIGITAL CONTROL SYSTEMS**

V. A. REGENIE, C. V. CHACON, and W. P. LOCK Aug. 1986 19 p To be Presented at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88271; H-1372; NAS 1.15:88271; AIAA-86-2239-CP)
Avail: NTIS HC A02/MF A01 CSCL 01C

Flight control systems have undergone a revolution since the days of simple mechanical linkages; presently the most advanced systems are full-authority, full-time digital systems controlling unstable aircraft. With the use of advanced control systems, the aerodynamic design can incorporate features that allow greater performance and fuel savings, as can be seen on the new Airbus design and advanced tactical fighter concepts. These advanced aircraft will be and are relying on the flight control system to provide the stability and handling qualities required for safe flight and to allow the pilot to control the aircraft. Various design philosophies have been proposed and followed to investigate system architectures for these advanced flight control systems. One major area of discussion is whether a multichannel digital control system should be synchronous or asynchronous. This paper addressed the flight experience at the Dryden Flight Research Facility of NASA's Ames Research Center with both synchronous and asynchronous digital flight control systems. Four different flight control systems are evaluated against criteria such as software reliability, cost increases, and schedule delays. Author

**N86-29867*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**MODEL-FOLLOWING CONTROL FOR AN OBLIQUE-WING AIRCRAFT**

G. S. ALAG, R. W. KEMPEL, J. W. PAHLE, J. J. BRESINA, and F. BARTOLI Aug. 1986 13 p Presented at the AIAA Conference on Guidance and Control, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88269; H-1362; NAS 1.15:88269; AIAA-86-2244CP)
Avail: NTIS HC A02/MF A01 CSCL 01C

A variable-skew oblique wing offers a substantial aerodynamic performance advantage for aircraft missions that require both high efficiency in subsonic flight and supersonic dash or cruise. The most obvious characteristic of the oblique-wing concept is the asymmetry associated with wing-skew angle which results in significant aerodynamic and inertial cross-coupling between the aircraft longitudinal and lateral-directional axes. A technique for synthesizing a decoupling controller while providing the desired stability augmentation. The proposed synthesis procedure uses the cncept of explicit model following. Linear quadratic optimization techniques are used to design the linear feedback system. The effectiveness of the control laws developed in achieving the desired decoupling is illustrated for a given flight condition by application to linearized equations of motion, and also to the nonlinear equations of six degrees of freedom of motion with nonlinear aerodynamic data. Author

**N86-29868*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**EIGENSYSTEM SYNTHESIS FOR ACTIVE FLUTTER SUPPRESSION ON AN OBLIQUE-WING AIRCRAFT**

G. S. ALAG (University of Western Michigan, Kalamazoo.), J. J. BURKEN, and G. B. GILYARD Aug. 1986 9 p Presented at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986

(NASA-TM-88275; H-1359; NAS 1.15:88275; AIAA-86-2243-CP)

Avail: NTIS HC A02/MF A01 CSCL 01C

The application of the eigensystem synthesis technique to place the closed-loop eigenvalues and shape the closed-loop eigenvectors has not been practical for active flutter suppression, primarily because of the availability of only one control surface (aileron) for flutter suppression. The oblique-wing aircraft, because of its configuration, provides two independent surfaces (left and right ailerons), making the application of eigensystem synthesis practical. This paper presents the application of eigensystem synthesis using output feedback for the design of an active flutter suppression system for an oblique-wing aircraft. The results obtained are compared with those obtained by linear quadratic Gaussian techniques. Author

**N86-29869#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**INTRODUCTION TO ROBUST MULTIVARIABLE CONTROL Final Report, Oct. 1983 - Sep. 1985**

D. B. RIDGELY and S. S. BANDA Feb. 1986 430 p

(AD-A165891; AFWAL-TR-85-3102) Avail: NTIS HC A19/MF A01 CSCL 01C

Linear multiple-input multiple-output (multivariable) control systems are considered. The intent of this report is to familiarize the working engineers with some of the developments in the area of robust multivariable control theory that have occurred in the past 10 years. The concepts of singular values are used to systematically develop robust control systems analysis and design techniques. The advantages and limitations of these techniques are discussed. Examples are used to illustrate the methods. Author (GRA)

**N86-29870#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abt. Elastomechanik und Aeroelastische Stabilitaet

**ACTIVE FLUTTER SUPPRESSION ON A DELTA WING MODEL STRUCTURE**

R. FREYMANN and K. CHENG Dec. 1985 72 p

(DFVLR-FB-86-01; ISSN-0171-1342; ESA-86-97455) Avail: NTIS HC A04/MF A01; DFVLR, Cologne, West Germany DM 26

Active flutter suppression systems were designed for a flexible model delta wing structure based either on the concept of fictitious structural modifications or on frequency response methods. For validation of the results from the analytical investigations, extensive tests were performed on the model delta wing structure in a 3m x 3m low speed wind tunnel. During the tests the flutter speed of the actively controlled wing was increased by 25% compared to the basic, uncontrolled system. Good agreement between calculated and measured results is found. ESA

**N86-30630#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).

**APPLICATION OF TRANSONIC UNSTEADY METHODS FOR CALCULATION OF FLUTTER AIRLOADS**

H. ZIMMERMANN and S. VOGEL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 47-61 1985

Avail: NTIS HC A99/MF E03

The supercritical MBB-A3 profile was used as an example for calculating steady and unsteady pressure distribution by unsteady transonic codes. Most of the calculations were performed using the nonlinear TSP-equation and its time linearized form solved by a time marching method and by an integral method. The influence of the coefficient of the nonlinear term, of the inclusion of the steady or quasi-steady boundary layer thickness, and of the fulfillment of the Rankine-Hugoniot condition on the resulting pressure distribution is shown. Flutter calculations were made for a two degree of freedom representative section. The resulting critical speeds show a considerable variation depending on which method was used. Results show that there are good arguments for using time-linearized TSP methods in flutter calculations in the transonic domain. ESA

**N86-30635#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelasticity.

**THEORETICAL FLUTTER INVESTIGATIONS ON A PLANE CASCADE IN INCOMPRESSIBLE FLOW**

V. CARSTENS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 169-179 1985

Avail: NTIS HC A99/MF E03

An analysis which predicts the aeroelastic behavior of a plane cascade in incompressible flow is presented. The unsteady aerodynamic forces and moments acting on the blades are calculated by the method of surface layers. In the general case of bending and/or torsional modes, this method is based on the simultaneous solution of two linear integral equations of the second kind which contain the interaction of steady and unsteady blade loading as well as the influence of all other specific cascade parameters. The solution of the flutter equations for a two degree of freedom model is discussed on the basis of a given cascade configuration. ESA

**N86-30637#** Northwestern Polytechnical Univ., Xian (China).

**A NUMERICAL ANALYSIS FOR VERTICAL GUST FIELD INDUCED BY GUST GENERATOR**

Y. YANG and J. WANG *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 187-193 1985

Avail: NTIS HC A99/MF E03

A method for calculating vertical gust field induced by a gust generator, which consists of a group of oscillating vanes, based on subsonic unsteady lifting surface theory is presented. When the geometry of the gust generator, oscillating frequency and amplitude, and Mach number are given, the unsteady downwash field can be determined. In the calculation, the interference among the vanes is considered. Through numerical calculation, the characteristics of the vertical gust field induced by one, two, or three vanes with various reduced frequencies and Mach numbers are investigated. The influence of the gust generator on the characteristics of the vertical gust field are discussed, and conclusions for gust wind tunnel design are outlined. ESA

**N86-30642#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.

**A REVIEW OF AEROELASTIC RESEARCH AT THE FLIGHT DYNAMICS LABORATORY**

T. M. HARRIS, T. E. NOLL, T. J. HERTZ, and W. A. SOTOMAYER *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 233-243 1985

Avail: NTIS HC A99/MF E03

Research on aeroservoelasticity, adaptive flutter suppression, the effects of stores carriage on body freedom flutter, and three dimensional transonic unsteady aerodynamics is discussed.

Aeroservoelasticity studies involve research to develop tools for aeroelastic analyses of aircraft when active feedback control systems are taken into account. Adaptive flutter suppression for aircraft carrying external stores is evaluated by wind tunnel tests. Subsonic wind tunnel tests were performed to evaluate the effect of store location, mass, and inertia on aeroelastic stability. ESA

**N86-30643#** Fairchild Republic Div., Farmingdale, N. Y.
**AEROELASTIC WIND TUNNEL SIMILARITY THEORY FOR ANISOTROPIC AIRCRAFT WINGS**
G. A. OYIBO *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 257-264 1985
Avail: NTIS HC A99/MF E03

A theory outlining a simplified approach for aeroelastically simulating anisotropic aircraft wings is presented. An examination of the fundamental aeroelastic equations of motion for anisotropic aircraft wings, with the help of affine transformations, reveals that a unified simulation theory, which reduces to the existing theory in the isotropic limit can be formulated. It is discovered that the necessary condition for preserving the Strouhal number (reduced frequency) between the real aircraft wing and its wind tunnel model is by preserving the generalized forms of the similarity parameters suggested by Theodorsen and Garrick as well as new parameters. The additional similarity parameters reflect directional and coupling stiffness properties of anisotropic materials in a given aerospace structure. The results reduce to those for aircraft wings fabricated of isotropic materials if these new parameters are set equal to zero. ESA

**N86-30644#** British Aerospace Dynamics Group, Hatfield (England). Civil Div.
**THE CHOICE OF TECHNIQUES USED FOR FLIGHT FLUTTER CLEARANCE WITH PARTICULAR REFERENCE TO THE BAE 146 AND BAE 125**
A. G. WOODS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 265-275 1985
Avail: NTIS HC A99/MF E03

The considerations necessary to arrive at a safe and cost effective method of flutter clearance are discussed. Flight flutter tests of the BAe 146 and BAe 125, for both of which a fast sweep technique was chosed, are described. Methods of excitation, recording, and analysis are given. ESA

**N86-30645#** Saab-Scania, Linkoping (Sweden).
**FLUTTER CALCULATION BY A NEW PROGRAM**
V. J. E. STARK *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 276-285 1985
Sponsored by Swedish Defence Administration and Saab Scania A.B.
Avail: NTIS HC A99/MF E03

A flutter and response program based on general equations of motion is described. The equations are solved by Laplace transformation and by reducing the inversion integral to a sum of the residues at the poles at the zeros of the determinant. The resulting nonlinear eingenvalue problem, i.e., the problem of finding the zeros, is solved by the Newton-Raphson formula with numerical methods for calculation of the determinant and the principle of the argument for finding initial approximations. The program permits choice of different kinds of analytic functions in the linear approximation that is employed for approximating the aerodynamic transfer functions. Equations representing control laws of a flutter suppression system can be included. ESA

**N86-30647#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**DEVELOPMENT OF A FLUTTER SUPPRESSION CONTROL LAW BY USE OF LINEAR QUADRATIC GAUSSIAN AND CONSTRAINED OPTIMIZATION DESIGN TECHNIQUES**
W. M. ADAMS and S. H. TIFFANY *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 297-308 1985
Avail: NTIS HCA99/MF E03 CSCL 01B

A control law to suppress symmetric flutter for a mathematical model of an aeroelastic research vehicle is developed. An implementable control law is attained by including modified linear quadratic Gaussian design techniques, controller order reduction, and gain scheduling. A complementary design approach for a flight condition wherein nongradient-based constrained optimization techniques are applied to maximize controller robustness is illustrated. ESA

**N86-30649#** National Aerospace Lab., Amsterdam (Netherlands). Dept. of Aeroelasticity.
**NLR EXPERIENCE IN THE APPLICATION OF ACTIVE FLUTTER SUPPRESSION AND GUST LOAD ALLEVIATION, APPLIED TO A WIND TUNNEL MODEL**
P. A. VANGELDER *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 320-329 1985
Sponsored by Netherlands Agency for Aerospace Programs and NLR
Avail: NTIS HC A99/MF E03

Control laws for flutter suppression and gust load alleviation systems were developed and tested using an aeroelastic model in a subsonic wind tunnel with the capability to simulate discrete or random gusts. Flutter suppression up to the maximum wind tunnel speed (1.4 m/sec) is achieved, while the gust load alleviation system reduces the wing root bending moment by 25% at 0.9 m/sec for simulated gusts with a Dryden spectrum. ESA

**N86-30650#** Royal Aircraft Establishment, Farnborough (England).
**THE DESIGN AND WIND TUNNEL DEMONSTRATION OF AN ACTIVE CONTROL SYSTEM FOR GUST LOAD ALLEVIATION AND FLUTTER SUPPRESSION**
I. W. KAYNES, C. W. SKINGLE, and J. C. COPLEY *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 330-347 1985
Avail: NTIS HC A99/MF E03

Wind tunnel tests on a flexible model with an active control system are described. A flutter suppression control law was designed and tested. It is shown that flutter suppression is achieved in the presence of gusts. The mathematical model of the aircraft includes descriptions of the whole aircraft motion and the flexible aircraft deformations. Physically realistic modifications were made to the mathematical model to enhance the agreement between predictions and the measured loads and responses. Physical understanding of the active controls is facilitated by an interactive control system design package. The predicted and measured performance of the control laws are presented. ESA

**N86-30651#** Northwestern Polytechnical Univ., Xian (China).
**CONTROL LAW SYNTHESIS FOR GUST LOAD ALLEVIATION USING LINEAR QUADRATIC GAUSSIAN THEORY**
J. CHANG *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 362-367 1985
Avail: NTIS HC A99/MF E03

A method of using linear quadratic Gaussian synthesis in the design of multiloop gust alleviation for a flexible aircraft is presented. To obtain an aeroelastic sytem with a finite-order state form matrix equation, the aerodynamic influence coefficients are approximated by a rational function of s. A technique to minimize the number of augmented states is presented. For all the coefficient matrices, a matrix least squares formula is established. The fitting accuracy of this methods is better than other methods. ESA

**N86-30657#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
**TAILORING METHODOLOGY FOR AEROELASTIC STABILITY AND LATERAL CONTROL ENHANCEMENT**
T. A. WEISSHAAR *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 415-425 1985
Avail: NTIS HC A99/MF E03

Uses of aeroelastic tailoring to enhance aircraft structural design for dynamic response are discussed. The incorporation of directional stiffness into a design may alter drastically the mode shapes and frequencies of lifting surface. This alteration affects dynamic aeroelastic interactions between modal forces as well as the modal forces themselves. Tailoring to increase flutter speed generally produces a degradation of the classical divergence speed. As a result, the freedom of the wing to move as a rigid body in concert with the fuselage may render the aircraft susceptible to an attitude instability called body-freedom flutter. Thus, aeroelastic tailoring may lead to aeroelastic behavior characteristics not unlike those of swept forward wings. Tailoring may improve controllability at reduced cost. It may provide increased effectiveness of active control by creating a harmonious control/structure environment. ESA

**N86-30736*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronatuical Engineering.
**LONGITUDINAL STABILITY AND CONTROL DERIVATIVES OBTAINED FROM FLIGHT DATA OF A PA-30 AIRCRAFT Final Report**
D. R. TURLEY and D. R. SANDLIN Apr. 1981 60 p
(Contract NCC4-1)
(NASA-CR-176999; NAS 1.26:176999) Avail: NTIS HC A04/MF A01 CSCL 01C

In order to obtain reliable and accurate values of the stability and control derivatives, the Dryden Fligh Research Center (DFRC) developed a technique for extracting the derivatives from flight data. This technique is implemented by a set of FORTRAN computer programs that is based on a modified maximum likelihood estimator that uses the Newton-Raphson algorithm to perform the required minimization of the derivatives. Data was obtained with a PA-30, light twin-engine general aviation aircraft in zero, half, and full flap configuration in level unaccelerated flight with the landing gear retracted. The derivatives were plotted as functions of angle of attack using various graphical arrangements to show variations of wind tunnel and flight determined values at zero flap settings. Also, data was displayed to show the effects of flap deflection and thrust variation on the longitudinal stability derivatives. The angle of attack and angle of sideslip were measured. The dynamic pressure, velocity, and altitude were calculated, using a FORTRAN computer program, from the static and dynamic pressures. The control deflections of the stabilator, ailerons, and rudder also were recorded along with left throttle position, engine rpm, and manifold pressure. B.G.

**N86-30737*#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
**THE INTEGRATED MANUAL AND ATUOMATIC CONTROL OF COMPLEX FLIGHT SYSTEMS Semiannual Status Report, Jul. 1984 - Mar. 1985**
D. K. SCHMIDT 12 Apr. 1985 68 p
(Contract NAG4-1)
(NASA-CR-176940; NAS 1.26:176940) Avail: NTIS HC A04/MF A01 CSCL 01C

The flight test results obtained recently (1984) by CALSPAN on pitch-rate flight control systems in the flared landing task, obtained with the Total In-Flight Simulator (TIPS), were analyzed. The analysis approach considered is based on the Optimal Control/Frequency Domain (OC/FD) techniques. These techniques originally stem from an optimal-control approach to perform a Neal-Smith-like analysis on aircraft attitude dynamics, but were extended and used successfully to analyze the flared landing task. B.G.

**N86-30738*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
**A SURVEY OF HANDLING QUALITIES CRITERIA AND THEIR APPLICATIONS TO HIGH PERFORMANCE AIRCRAFT Final Report**
D. L. PEAHL, F. KOLKAILAH, and D. R. SANDLIN Jan. 1986 68 p
(Contract NCC2-338)
(NASA-CR-179654; NAS 1.26:179654) Avail: NTIS HC A04/MF A01 CSCL 01C

Various handling qualities criteria and their application to high performance aircraft including state-of-the-art and highly augmented aircraft were surveyed. Neal-Smith, Bandwidth, Equivalent Systems, and Military Specification 8785 criteria are applied to flight test data from aircraft such as the F-8 Digital Fly-By-Wire, the YF-12, and an Advanced Fighter Aircraft. Backgrounds and example applications of each criteria are given. The results show that the handling qualities criteria investigated can be applied to highly augmented aircraft with fairly good results in most cases; however, since no one method excelled, more than one criteria should be used whenever possible. Equivalent time delays appear to be the most frequent critical factor in determining pilot rating levels of highly augmented aircraft. Author

**N86-30739#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**AIRCRAFT RESPONSE TO TURBULENCE**
1985 32 p Presented at the 61st Meeting of the Structures and Materials Panel of AGARD, Oberammergau, West Germany, 8-13 Sep. 1985
(AGARD-R-738; ISBN92-835-0393-7) Avail: NTIS HC A03/MF A01

In 1985 the Structures and Materials Panel initiated an activity to consider the flight of flexible aircraft in turbulence. As a preliminary to the start of this activity, the Panel heard the two papers included in this report. One of the two papers discusses measurements of time histories of turbulence made by specially equipped aircraft and turbulence event statistics obtained from aircraft in commercial operation. The other paper considers aspects of collection and analysis of flight data, methods of calculating aircraft response and constraints in operation. Author

**N86-30741#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
**GUST LOAD PREDICTION AND ALLEVIATION ON A FIGHTER AIRCRAFT**
J. BECKER Jun. 1986 22 p Presented at the 61st Meeting of the Structures and Materials Panel of AGARD, Oberammergau, West Germany, 8-13 Sep. 1985
(AGARD-R-728; ISBN92-835-1532-3) Avail: NTIS HC A02/MF A01

In 1985 the AGARD Structures and Materials Panel initiated an activity on the flight of flexible aircraft in turbulence. As a preliminary the Panel heard this paper which discusses the influence of turbulence -induced dynamic loads on the structural design of fighter aircraft. Methods for calculating dynamic response are given, and the problems associated with improved ride are considered. Author

## 09

## RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

**A86-44458**

### LANDING GEAR TEST FACILITIES EXAMINED

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, June 1986, p. 21-26.

The technology of landing-gear testing in the U.S. is reviewed. Consideration is given to roadwheel and table dynamometers for roll, dynamic-torque, and vibration tests; drop towers to test shock-absorption characteristics; and the full-scale takeoff and landing simulation apparatus at the NASA Langley Aircraft Landing Dynamics Facility (ALDF). The ALDF equipment, including a 100,000-lb test carriage with a 40 x 20-ft mounting bay, a propulsion system providing 2 x 10 to the 6th lb thrust, a 2800-ft test track with different road surfaces and water/ice/slush coverage, and facilities for a wide range of specific hardware tests, is described and illustrated with photographs. T.K.

**A86-44933**

### COMPARISON OF MODAL ANALYSIS METHODS ON A LIGHT AIRCRAFT

W. J. STEVENSON (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) Aeronautica Meridiana (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 19-28. refs

In the present comparison between the classical multiple exciter sine well and transfer function ground vibration testing methods, attention is given to divergences of approach. While less testing time was required by the classical method, the transfer function method's present results are encouraging and subject to further improvement by means of software refinements. Only one exciter position was used in the present testing of the transfer function method. O.C.

**A86-45137**

### FLIGHT SIMULATION

R. N. HABER (Illinois, University, Chicago) Scientific American (ISSN 0036-8733), vol. 255, July 1986, p. 96-103.

The technology of flight simulation has undergone great advances since the Link trainer of World War II vintage. The skills that crew members of today's advanced aircraft must have to accomplish their missions may be acquired and sharpened aboard actual aircraft, but this is often difficult, time-consuming, expensive and dangerous. The use of simulators overcomes all of these disadvantages. A flight simulator consists of a cockpit and a control room; the cockpit is enclosed by a projection surface (either a series of cathode ray tubes or a number of projection screens) to show the trainee the panorama that would be visible from the aircraft in flight. Motion is simulated, instrument readings change, and the displayed view changes all in accordance with actions taken by the pilot and with problem inputs initiated by an instructor pilot. Problems of achieving great realism (visual resolution, 3-D effect, scope of the display) are noted. A recent innovation, the heads-up helmet-mounted display, is getting considerable attention. Numerous emergencies, weather changes, and combat situations can be created in rapid sequence to challenge the trainee to respond correctly. It is noted that in combat, if a pilot successfully accomplishes five missions the odds are better than 95 percent that he will survive all his future missions; it appears that many lives could be saved if the equivalent of those first five missions could be 'flown' on simulators. D.H.

**A86-45425*#** Southwest Research Inst., San Antonio, Tex.

### PROPELLER-INDUCED STRUCTURE-BORNE NOISE LABORATORY-BASED TEST APPARATUS

J. F. UNRUH (Southwest Research Institute, San Antonio, TX) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs

(Contract NAS1-17921)

(AIAA PAPER 86-1938)

A potentially important source of structure-borne interior noise transmission in advanced turboprop aircraft is the impingement of the propeller wake/vortex on downstream aerodynamic surfaces. The expected levels of propeller wake/vortex-induced structure-borne noise transmission are not known nor can they be determined with present-day technology. A test apparatus has been designed, built and calibrated for the purposes of studying propeller-induced, structure-borne noise transmission in prototypical aircraft structures. The principal approach to the test apparatus design was to provide a physical means of separating the airborne and structure-borne noise components so that the structure-borne noise transmission response could be studied directly without airborne noise contamination. This was accomplished by housing the receiving fuselage structure in an acoustic shield fitted with a wing-to-fuselage acoustic seal. Initial evaluation of the wing-to-fuselage acoustic seal indicates adequate airborne noise isolation to allow direct study of structure-borne noise transmission. Author

**A86-45673**

### ARNOLD ENGINEERING DEVELOPMENT CENTER - SIMULATORS ENCOMPASS SPECTRUM OF AEROSPACE ENVIRONMENTS

Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, July 7, 1986, p. 59, 64, 69, 73.

The types, capabilities and applications of the aerospace simulation facilities at Arnold Engineering Development Center (AEDC) are outlined. The hardware inventory covers 11 turbine and rocket test cells, four high speed wind tunnels, four ballistic and impact ranges, and one supersonic and three transonic wind tunnels. AEDC is operated by contractors working closely with Air Force R&D personnel. Efforts are continuously expended to project generic requirements and prepare for future developments in aeromechanics, propulsion, space and reentry vehicle technologies. Testing is underway to identify technologies which meet the needs of efficient engines for vectored thrust aircraft, high altitude liquid-fueled rocket engines, orbit transfer vehicles, simulation of the environment for the national aerospace plane, and the effects of collisions betweeen birds and aircraft. Upgrades to the supersonic wind tunnel facility are described, along with recent flight dynamics accomplishments for military programs. M.S.K.

**A86-45674**

### ARNOLD ENGINEERING DEVELOPMENT CENTER - NEW FACILITY TO ASSESS ENGINE-AIRFRAME COMPATIBILITY PRIOR TO FIRST FLIGHT

Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, July 7, 1986, p. 74, 75, 77.

Design and projected performance features of the Aeropropulsion Systems Test Facility (ASTF) at the Arnold Engineering Development Center are summarized. Built to simulate flight speeds up to Mach 3.8 and altitudes to 100,000 ft, the Facility is to meet national test requirements for airflow, simulated airspeed, thrust, altitude, and air temperature in its performance envelope into the 21st century. The test cells are each 28 ft in diameter and 85 ft long, with a total of 2170 data channels. Vehicles in a test cell are operated with controls similar to those in aircraft and feedback data are provided in real time. The capability is also available for testing engines over all transient states in a flight trajectory, rather than varying the conditions from one steady state to another. A primary goal in the development of the $600 million facility is to discover design flaws early in the development process and thus recoup the costs of the ASTF within a short number of years. M.S.K.

**A86-46155#**

### REQUIREMENTS AND RECOMMENDATIONS FOR THE DEVELOPMENT OF THEORETICAL CODES AND EXPERIMENTAL FACILITIES IN THE NEAR FUTURE

B. COSTES (ONERA, Chatillon-sous-Bagneux, France) (Institut von Karman de Dynamique des Fluides, Cours, Brussels, Belgium, Athens, Greece, and Ankara, Turkey, Feb. 17-28, 1986) ONERA, TP, no. 1986-10, 1986, 16 p. refs
(ONERA, TP NO. 1986-10)

The development of computational fluid mechanics (CFM) techniques and facilities and complementary wind-tunnel facilities is projected over the period 1985-2000, summarizing the findings of a number of published reviews and reports. The strength, limitations, and inconsistencies of current CFM programs are surveyed; the need for greater reliability and for more cooperation among research teams and between basic science and industry is stressed; the reasons for continuing and improved wind-tunnel verification of CFM results are outlined; the advantages of current advanced-design wind tunnels (such as ONERA F2, NASA National Transonic Facility, DFVLR cryogenic tunnel, and some adaptive-wall facilities) are considered; and the need for better flow-visualization techniques is indicated. Diagrams, drawings, and graphs of sample data are provided. T.K.

**A86-46719**

### PROBLEMS OF THE VISUAL DISPLAY IN FLIGHT SIMULATION

R. E. CLAPP (Boeing Military Airplane Co., Wichita, KS) IN: Image quality: An overview; Proceedings of the Meeting, Arlington, VA, April 9, 10, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 64-70. refs

The visual display presents a major source of critical information to the pilot in a flight training simulator. At the same time, due to underspecification or underdesign of the visual display system, the information presented to the pilot is grossly incomplete. These problems in the visual display are the result of misapplication or misunderstanding of the pilots visual perceptions and the limitations of resolution and scene detail of the visual display. This paper presents a summary of the principles of limiting resolution and the definition of scene detail, as well as a discussion of other visual parameters; and the importance of these factors in obtaining satisfactory standards in initial and continuation training in a flight simulator. Author

**A86-47093**

### DIGITAL DATA ACQUISITION SYSTEM FOR MODAL TESTING

D. BANASZAK and R. D. TALMADGE (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1 . Schenectady, NY, Union College, 1985, p. 108-116. refs

The instrumentation system for ground vibration testing (GVT) of a F-16 aircraft is examined. The GVT system provides the multiple accelerometer and force signal measurements for aircraft modal analyses. The instrumentation system is composed of 120 piezoelectric accelerometers with FET followers, 120 six pole low-pass-filters, 120 automatic gas-changing amplifiers, a digital multiplexer, and a programable data acquisition system (DAS). The configuration and functions of the equipment are described. The evaluation and calibration of the DAS are discussed. I.F.

**A86-47127**

### PROPELLER FOD QUALIFICATION USING MODAL ANALYSIS, ARTIFICIAL BIRDS, AND A STATIC IMPACT FACILITY

M. L. DRAKE and R. S. BERTKE (Dayton, University, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2 . Schenectady, NY, Union College, 1985, p. 1072-1081. refs

The results of a program to investigate the impact response of a composite propeller blade to bird impacts are discussed. The program consisted of four major tasks, each of which is described in detail. The first task consisted of establishing the blade station in the spanwise direction which would cause the most severe structural response for the first three modes of the propeller. The second and third tasks consisted of impact tests of either 4 or 1.5 lb artificial birds to determine the structural and local response of the propeller blades. The fourth task consisted of determining the damage generated and documenting the damage. Rap testing indicated that the tip area would produce the maximum structural response. C.D.

**N86-29871*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### ADAPTIVE WALL WIND TUNNELS: A SELECTED, ANNOTATED BIBLIOGRAPHY

M. H. TUTTLE (Vigyan Research Associates, Inc., Hampton, Va.) and R. E. MINECK Aug. 1986 55 p
(NASA-TM-87639; L-16084; NAS 1.15:87639) Avail: NTIS HC A04/MF A01 CSCL 14B

This bibliography, with abstracts, consists of 257 citations arranged in chronological order. Selection of the citations was made for their value to researchers working to solve problems associated with reducing wall interference by the design, development, and operation of adaptive wall test sections. Author, source, and subject indexes are included. Author

**N86-29872*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### CRYOGENIC WIND TUNNELS FOR HIGH REYNOLDS NUMBER TESTING

P. L. LAWING, R. A. KILGORE, and P. D. MCGUIRE May 1986 95 p
(NASA-TM-87743; NAS 1.15:87743) Avail: NTIS HC A05/MF A01 CSCL 14B

A compilation of lectures presented at various Universities over a span of several years is discussed. A central theme of these lectures has been to present the research facility in terms of the service it provides to, and its potential effect on, the entire community, rather than just the research community. This theme is preserved in this paper which deals with the cryogenic transonic wind tunnels at Langley Research Center. Transonic aerodynamics is a focus both because of its crucial role in determining the success of aeronautical systems and because cryogenic wind tunnels are especially applicable to the transonics problem. The paper also provides historical perspective and technical background for cryogenic tunnels, culminating in a brief review of cryogenic wind tunnel projects around the world. An appendix is included to provide up to date information on testing techniques that have been developed for the cryogenic tunnels at Langley Research Center. In order to be as inclusive and as current as possible, the appendix is less formal than the main body of the paper. It is anticipated that this paper will be of particular value to the technical layman who is inquisitive as to the value of, and need for, cryogneic tunnels. Author

**N86-30663#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.

### SIMULATION OF AIRCRAFT TAXI TESTING ON THE AGILE SHAKER TEST FACILITY

R. FREYMANN and W. P. JOHNSON (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio) *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 468-476 1985
Avail: NTIS HC A99/MF E03

Use of the Aircraft Ground Induced Loads Excitation test facility, an array of three independent shakers which allows laboratory simulation of an aircraft taxiing on rough surfaces, in the dynamic qualification process and for verification of the mathematical structural model of an aircraft is described. Experimental determination of the elastomechanical characteristics of aircraft landing gears and tires is outlined. ESA

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# ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A86-46149**

### DIGITAL CONTROL LOADING AND MOTION - THE FINAL WORD?

J. COOPER, M. RUTHERFORD, and M. MCKINNON (CAE Electronics, Ltd., Montreal, Canada) ICAO Bulletin, vol. 41, May 1986, p. 30-33.

Attention is given to a novel flight simulator loading control and motion system which yields considerable logistics and performance benefits as well as dynamic flight simulations that are superior to those of modern analog systems. A 3-kHz iteration rate allows the modeling of nonlinear characteristics which are difficult to reproduce cost-effectively in the case of an analog model. Attention is given to the characteristics of the general control-loading model, the overall system's configuration, the sophisticated mechanical design employed, and safety considerations. O.C.

**N86-30684#** Technische Hochschule, Aachen (West Germany). Inst. fuer Leichtbau.

### RECONSTRUCTION OF FORCING FUNCTIONS BASED ON MEASURED STRUCTURAL RESPONSES

H. OERY, H. GLASER, and D. HOLZDEPPE *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 656-668 1985 Sponsored by Deutsche Forschungsgemeinschaft, ESA, and MBB/Erno G.m.b.H.

Avail: NTIS HC A99/MF E03

A structural analysis procedure to reconstruct the significant parts of the forcing function time-histories based on a restricted number of test records is presented. Use of the inverse application of the phase-plane method and Williams' method is proposed. The procedure is based on the fact that very slowly varying loads induce deformations, which can be determined using the stiffness matrix only. It can be applied to aerospace structures and to earthquake engineering. ESA

# 11

# CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

**A86-45185**

### INVESTIGATION OF THE IGNITION CHARACTERISTICS OF HYDROGEN/AIR MIXTURES IN THE CASE OF COMBUSTION INDUCED BY OBLIQUE SHOCKS [UNTERSUCHUNG DES ZUENDVERHALTENS VON WASERSTOFF/LUFT-GEMISCHEN BEI SCHRAEGSTOSSINDUZIERTER VERBRENNUNG]

J. ALGERMISSEN (Stuttgart, Universitaet, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Mar.-Apr. 1986, p. 73-81. In German. refs
(Contract DFG-SFB-85)

Questions regarding the combustion induced by oblique shocks are of interest in connection with the development of new types of propulsion systems for the hypersonic flight in the atmosphere. The idea of a utilization of atmospheric oxygen as oxidizer in the case of hypersonic flight vehicles, has led to the concept of a 'scramjet'. The propulsion system envisaged provides for the flight Mach number range above four to six the optimum specific impulse with respect to all chemical propulsion systems. This system represents the theoretically best solution also on the basis of other considerations. A promising approach in studies for the technological implementation of the theoretical concepts is related to the utilization of supersonic flows with adaptable oblique shock ignition systems. An experimental installation for the study of supersonic combustion processes is discussed. The installation provides a steady free-jet flame, which is uniformly ignited over the entire cross section. G.R.

**A86-45395**

### CARBON RESIDUE STUDIES WITH A MICROCARBON RESIDUE TESTER

W. BOCHARTZ (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) ASLE, Annual Meeting, 41st, Toronto, Canada, May 12-15, 1986. 6 p. refs
(ASLE PREPRINT 86-AM-7A-1)

A test procedure for coking propensity of gas turbine lubricants was developed using a commercial microcarbon residue tester (MCRT) used for the American Society of Testing and Materials Test Method D-4530, 'Standard Test Method for Micro Carbon Residue of Petroleum Products'. The MCRT, a microprocessor-controlled heating unit, was evaluated for its ability to determine carbon residue in weight percent of synthetic gas turbine lubricants under controlled static conditions. The purpose was to obtain information on the amount of deposit remaining in glass vials after a measured volume of lubricant had been exposed to different degrading environments, varying the parameters of temperature, gas (air or nitrogen), and exposure time. During a test, several processes occur simultaneously. The major effect is volatilization of the lubricant. Substantial oxidation and thermal degradation of the lubricant also occur, causing residue to form in the glass vials. A criterion for evaluating the test lubricants is the weight of the vial deposits. The basic studies were conducted with four lubricants meeting MIL-L-7808J specification and two lubricants meeting MIL-L-23699C specification. The evaluation shows that the MCRT has potential use as a cost-effective laboratory tester to differentiate lubricants regarding tendency to form coke deposits prior to engine tests. Comparison of test data from the MCRT and the static coker deposition tester indicates that the tests have a good correlation, which is most likely due to the similar test conditions. Author

**A86-46827**

### THE NEED FOR RAPIDLY SOLIDIFIED POWDER METALLURGY ALUMINUM ALLOYS FOR AEROSPACE APPLICATIONS

W. E. QUIST (Boeing Commercial Airplane Co., Seattle, WA) and R. E. LEWIS (Lockheed Research Laboratories, Palo Alto, CA) IN: Rapidly solidified powder aluminum alloys; Proceedings of the Symposium, Philadelphia, PA, April 4, 5, 1984 . Philadelphia, PA, American Society for Testing and Materials, 1986, p. 7-37; Discussion, p. 37, 38. refs

A need exists within the aerospace industry for the engineering properties promised by aluminum alloys produced by rapid solidification technology (RST). The extent to which these alloys will achieve technical and commercial success depends, however, upon: (1) achievement of the engineering property goals, (2) the degree of success in the development of competitive materials, including other aluminum products, and (3) the economics of using such alloys for any given application, including the total production, fabrication, and life cycle costs for the material. Useful applications of the new RST aluminum alloys are envisioned for each of the three primary groups of aerospace vehicles: aircraft, missiles, and space vehicles. Each of these groups has a different general set of material property and cost objectives. The current powder metallurgy (PM) aluminum alloy development efforts for aerospace applications can be divided conveniently into three categories or classes of alloys: (1) high-strength, corrosion-resistant alloys; (2) low-density, high-modulus alloys; and (3) elevated-temperature, creep-resistant alloys. The development objectives for each of these alloy categories depend on the specific needs of the aerospace market for that category. The current status of progress in the development of the RST aluminum alloys indicates that some technical and economic success will be achieved in each category. The extent of this success is yet to be established. An assessment of various factors that affect the future course of development for these materials is presented. Author

**A86-46842**
**DEVELOPMENTS IN PREMIUM HIGH-STRENGTH POWDER METALLURGY ALLOYS BY KAISER ALUMINUM**
S. W. PING (Kaiser Aluminum and Chemical Corp., Pleasanton, CA) IN: Rapidly solidified powder aluminum alloys; Proceedings of the Symposium, Philadelphia, PA, April 4, 5, 1984 . Philadelphia, PA, American Society for Testing and Materials, 1986, p. 369-380. refs

The development of PM alloys from 1953-1983 is discussed. The initial formation of high-modulus, high-temperature alloys, alloy supersaturation studies on binary, ternary, and more complex alloys, and the fabrication of PM processed extrusions with good room-temperature properties are considered. The use of the depurative/vacuum degassing technique to form the PM alloys is described. The development of 7XXX- and 2XXX-based PM alloys with increased minimum strength levels is studied. The properties of the Al-Zn-Cu-Mg-Zr-Cr-Co (PM 64) alloy applicable for aircraft development are examined. Studies were conducted from 1981-1983 to modify the PM 64 alloy in order to improve its fatigue crack growth resistance. I.F.

**N86-30007#** Federal Aviation Administration, Washington, D.C. Program Engineering and Maintenance Service.
**PROCEEDINGS OF FUEL SAFETY WORKSHOP**
31 Dec. 1985 382 p Workshop held in Alexandria, Va., 29 Oct. - 1 Nov. 1985 Prepared in cooperation with Analysis Group, Inc., Washington, D.C.
(DOT/FAA/PM-86/13) Avail: NTIS HC A17/MF A01 CSCL 21D

The workshop served a four-fold purpose: (1) to discuss the results of the Federal Aviation Administration/NASA Controlled Impact Demonstration (CID) conducted December 1984 at Edwards Air Force Base, California; (2) to explore potential approaches to preventing post-crash aircraft fuel fires, including possible combinations of various approaches; (3) to re-evaluate past approaches in terms of current technology; and (4) to propose a course of action for future industry/government research, especially any future FAA research and development program. These proceedings contain the formal conference presentations followed by the recommendations of the attendees as agreed upon in the three informal working breakout sessions.

**N86-30008#** Federal Aviation Administration, Washington, D.C.
**ANTIMISTING FUEL TECHNOLOGY FOR TRANSPORT CATEGORY AIRCRAFT**
E. P. KLUEG *In its* Proceedings of Fuel Safety Workshop p 11-60 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

The antimisting kerosene (AMK) program is described. Details of the production and testing of AMK are given. Rheological studies on properties of antimisting, filtration, flammability, and viscoelasticity; heat transfer and frictional characteristics; and degradation levels are described. AMK flammability tests were performed in both the laboratory and in air crashes. Production details presented include in-line blending limitations and compatibility and degradation considerations. The organizational structure of the AMK development effort is described, and economic aspects of converting to AMK are discussed. J.P.B.

**N86-30009#** Federal Aviation Administration, Washington, D.C.
**AMK FULL-SCALE TRANSPORT AIRCRAFT VALIDATION PHASE SUMMARY**
B. C. FENTON *In its* Proceedings of Fuel Safety Workshop p 61-114 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

Fuel system modifications for CV-880 and B-720 aircraft were designed, built, and flight/crash tested in a controlled impact demonstration (CID),in order to assess the feasibility of antimisting kerosene (AMK) in fire retardation. Central to the fuel system modification was the degrader design. The inline blending of AMK at fueling point demonstrated consistently high fuel quality. The degrader demonstrated successful flight operation, and engine performance under degraded AMK was comparable to performance with jet A under nominal flight conditions. It is concluded that transport aircraft can operate on AMK with minor modifications, although there are accident scenarios where AMK may not prevent a fuel spill fireball attachment to the wing/fuselage. J.P.B.

**N86-30010#** Federal Aviation Administration, Washington, D.C.
**POST CONTROLLED IMPACT DEMONSTRATION (CID) ANALYSIS**
W. T. WESTFIELD *In its* Proceedings of Fuel Safety Workshop p 115-135 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

The unplanned deviations in a Controlled Impact Demonstration (CID) to test an antimisting kerosene (AMK) are reported. Post-impact tests were conducted to assess the performance of the fire-retardant fuel; some of these tests were modified because of the deviations from the planned impact. The history of the planning of the CID is given. Experiments to explain the (often unexpected) behavior of the fuel on impact were conducted. It is concluded that the CID was not typical of accident impacts and that the antimisting fuel was exposed to circumstances which it was not designed to withstand. Even so, the antimisting fuel presented a less hostile environment through its slower vaporization and heat release. J.P.B.

**N86-30011#** Federal Aviation Administration, Washington, D.C.
**FAA FUEL CONTAINMENT R AND D**
L. M. NERI *In its* Proceedings of Fuel Safety Workshop p 137-148 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

Fuel containment research by the Federal Aviation Administration (FAA) is summarized. The objective is to make post-crash fires less fatal and injurious. Three types of aircraft (transport airplanes, rotorcraft, and general aviation airplanes) are addressed independently. Data presented include: (1) compilation of accident data generated by airplane manufacturers; (2) accident percentage versus major failure modes; (3) accident percentage versus fire and fatalities; (4) impact events which possess the highest fuel spill potential; (5) generic technical approach addressing fuel containment; and (6) sequence of events leading to design criteria to satisfy program objectives. J.P.B.

**N86-30012#** Royal Aircraft Establishment, Farnborough (England). Materials and Structures Dept.
**UK WORK ON SAFETY FUELS**
S. P. WILFORD *In* FAA Proceedings of Fuel Safety Workshop p 163-179 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

Work on safety fuels in the United Kingdom is described with respect to antimisting fuel development, fuel systems design, degradation, blending, and engine combustion. Current research focuses on cavitation studies, where preliminary results indicate that use of FM9 antimisting kerosene (AMK) may lead to increased cavitation damage; and quality control, where a Capillary Trajectory Rig (CTR) has advanced quality testing to the point where a margin of fire safety may be determined. Finally, investigation of the unexpected results of the Controlled Impact Demonstration (CID) is briefly reported. J.P.B.

**N86-30013#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**HEAT TRANSFER, FRICTION, AND RHEOLOGICAL CHARACTERISTICS OF ANTIMISTING KEROSENE**

E. MATTHYS and V. SAROHIA *In* FAA Proceedings of Fuel Safety Workshop p 181-183 31 Dec. 1985
(Contract NAS7-918; DTFA03-80-00215)
Avail: NTIS HC A17/MF A01 CSCL 21D

Experiments were performed to determine the skin friction and heat transfer behavior of antimisting kerosene (AMK) in pipe flows. The additive used was FM-9. Based on the results of the experiments, which identify high viscosity and viscoelasticity for AMK, it is recommended that AMK be degraded. Sufficient degradation produces behavior similar to that of jet A. J.P.B.

**N86-30015#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**CONTINUOUS INLINE BLENDING OF ANTIMISTING KEROSENE**

P. PARIKH, A. YAVROUIAN, and V. SAROHIA *In* FAA Proceedings of Fuel Safety Workshop p 203-217 31 Dec. 1985
(Contract NAS7-917; DTFA03-80-A-00215)
Avail: NTIS HC A17/MF A01 CSCL 21D

A continuous inline blender was developed to blend polymer slurries with a stream of jet A fuel. The viscosity of the slurries ranged widely. The key element of the blender was a static mixer placed immediately downstream of the slurry injection point. A positive displacement gear pump for jet A was employed, and a progressive cavity rotary screw pump was used for slurry pumping. Turbine flow meters were employed for jet A metering while the slurry flow rate was calibrated against the pressure drop in the injection tube. While using one of the FM-9 variant slurries, a provision was made for a time delay between the addition of slurry and the addition of amine sequentially into the jet A stream. J.P.B.

**N86-30016#** Conoco, Inc., Ponca City, Okla.

**OLEFIN POLYMERS AS JET FUEL ANTIMIST ADDITIVES**

S. L. BAXTER and J. M. IWASYK (Du Pont de Nemours (E. I.) and Co., Wilmington, Del.) *In* FAA Proceedings of Fuel Safety Workshop p 221-240 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

Ultra-high molecular weight, oil-soluble polymers (designated AM-2) have been developed which may have potential as antimist additives. Tests show that these polymers significantly reduce the concentration of fines in fuel spray and increase mean particle diameter. Impact of the additives on other fuel properties is briefly discussed. J.P.B.

**N86-30017#** ICI Americas, Inc., Wilmington, Del.

**AMK: STILL VIABLE?**

C. G. RIVERS, JR. *In* FAA Proceedings of Fuel Safety Workshop p 241-249 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

The status of antimisting kerosene (AMK) as a fire-retardant fuel is discussed. Research to date indicates the likelihood that antimisting is effective; future research must be aimed at identifying the envelope of effectiveness. Existing technology appears adequate to provide for the onboard blending requirement for using AMK. Few problems in the area of aircraft operability using AMK have been encountered to date; however, a number of potential problems related to gelling remain. Extended engine testing may effectively address remaining concerns. J.P.B.

**N86-30018#** McDonnell-Douglas Corp., Long Beach, Calif.

**SAFETY FUELS-SPECIFICATIONS AND PROGRESS**

A. T. PEACOCK *In* FAA Proceedings Fuel Safety Workshop p 255-260 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

This paper discusses fuel standardization and quality control and the mechanisms already in place to attain them. It reflects 20 years of development of safety fuels and considers where the Federal Aviation Administration (FAA) should go from here. The need for a standard technical description of aviation turbine fuels that are developed to enhance fuel safety is discussed. Fuel property descriptions, test methods, and standardization procedures are also discussed, along with approvals for additives and fuel quality control. The role of the American Society for Testing and Materials (ASTM) in standardization is outlined, and a short history of safety fuels is given. It is suggested that fuel modification should not be abandoned as a method of improving safety. Author

**N86-30021#** General Technology Applications, Inc., Reston, Va.

**GTA/BASF ANTIMISTING FUEL RESEARCH**

J. C. TRIPPE *In* FAA Proceedings of Fuel Safety Workshop p 301-311 31 Dec. 1985
Avail: NTIS HC A17/MF A01 CSCL 21D

The research resulting in a process for dissolving polyisobutylene (PIB) in antimisting fuel is described. Reasons for continued private industry research into antimisting fuel are outlined. The background of investigations of the relationship between high molecular weight polymer additives, droplet size, and mist-induced fires is reported. The promise of PIB in antimisting fuels is summarized on the basis of theses characteristics: (1) satisfactory effectiveness at very low concentrations; (2) satisfactory effectiveness under high shear forces; (3) compatibility with current fuel specifications and unmodified fuel systems; (4) low cost under current high volume production; (5) ease of handling and application; and (6) elimination of catastrophic fuel explosions. J.P.B.

**N86-30024#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ANTIMISTING KEROSENE: EVALUATION OF IMPROVED FM-9 ADDITIVE Final Report, Aug. 1983 - Nov. 1984**

A. YAVROUIAN, P. PARIKH, and V. SAROHIA Jun. 1986 51 p
(Contract DTFA3-80-A-00215)
(DOT/FAA/CT-85-4; JPL-D-2581) Avail: NTIS HC A04/MF A01

During the past few years, studies by the Federal Aviation Administration (FAA) and other government agencies have shown that the hazards from aircraft crash fires might be significantly decreased if an antimisting kerosene (AMK) fuel could be utilized. The addition of polymeric additive at low concentrations to jet fuels is known to suppress mist formation and ignition of the fuels under circumstances often encountered in survivable aircraft crash landings. An antimisting additive, FM-9 (Trademark) has been developed by Imperial Chemical Industries (ICI) and is available under the trade name AVGARD. This material when dissolved in jet fuels imparts a strong time-dependent threshold type shear-thickening behavior. In case of fuel spillage from a ruptured fuel tank during an aircraft crash, the fuel misting is prevented. Simulated aircraft crash landing fuel spillage tests have indicated that fuel misting can be sufficiently suppressed, and the ignition and the subsequent fireball formation can be greatly reduced or eliminated. Optimization of FM-9 dissolution rate to attain acceptable mist suppression and degradation properties within 15 to 20 minutes of inline blending was carried out by ICI. This report discusses the evaluation of FM-9 variant which has better dissolution rate and consequently better degradability and compatibility with engine filters and fuel control system and was identified as a candidate additive to be used in a Control Impact Demonstration (CID) test. Author

**N86-30812*#** Textron Bell Helicopter, Fort Worth, Tex.

**FLIGHT SERVICE EVALUATION OF COMPOSITE COMPONENTS ON THE BELL HELICOPTER MODEL 206L Annual Flight Service Technical Summary Report**

H. E. WILSON, II Aug. 1986 53 p
(Contract NAS1-15279)
(NASA-CR-178148; NAS 1.26:178148; AFSR-2) Avail: NTIS HC A04/MF A01 CSCL 11D

This is the second annual report on the flight service components for the Bell Model 206L JetRanger helicopter. The components have been placed in service in the Continental United States, Canada, and Alaska. The report covers the period from 1 August 1983 to 1 January 1986. The status of 34 sets of components is discussed in this report. Approximately 73,000 flight hours were accumulated on the components as of 1 January 1986. Three years of coupon tests on the components are presented with test results. A vertical fin had been struck by lightning and the results of its examination and tests are included. Author

**N86-30821#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**THE USE OF A PYROCHEMILUMINESCENT NITROGEN ANALYZER AS A CAPILLARY GC (GAS CHROMATOGRAPH) DETECTOR Final Report, Mar. - May 1985**
E. W. PITZER Feb. 1986 21 p
(AD-A166597; AFWAL-TR-85-2077) Avail: NTIS HC A02/MF A01 CSCL 07D

A study was conducted to determine the feasibility of interfacing a pyrochemiluminescent nitrogen analyzer to a high resolution glass capillary gas chromatograph. The instruments used were a Varian Model 3700 gas chromatograph and an Antek Model 703C pyrochemiluminescent nitrogen analyzer. Known standards of nitrogen containing compounds were prepared in shale derived jet propulsion fuel that had been previously determined to have no nitrogen containing species. These solutions were then chromatographed on the GC/CLD system. The resulting data were reduced using relative response factors with an internal standard. The nitrogen content of the standard solutions were validated by analyses on a separate Antek nitrogen analyzer used to determine total nitrogen content. The method of GC/CLD was deemed feasible. However, it is recommended that appropriate design changes be made to the Antek Model 703C nitrogen analyzer to accommodate the type of flows common with capillary gas chromatographs. GRA

**N86-30838#** Dayton Univ., Ohio. Research Inst.
**ADVANCES IN THE STUDY OF THE MECHANICAL BEHAVIOR OF MATERIALS Final Report, 15 Jun. 1981 - 30 Sep. 1984**
N. E. ASHBAUGH, M. KHOBAIB, T. WEERASOORIYA, G. A. HARTMAN, A. M. RAJENDRAN, D. C. MAXWELL, and R. C. GOODMAN Dec. 1985 138 p
(Contract F33615-81-C-5015; AF PROJ. 2307)
(AD-A164656; AFWAL-TR-85-4124) Avail: NTIS HC A07/MF A01 CSCL 11F

The design of high performance aircraft engines requires the development of reliable life-predication methodology to aid in the evaluation and safety of the critical gas-turbine engine components. A comprehensive multi-task research and development program was conducted to establish a sound life-prediction methodology. The program consisted mainly of: (1) Experimental investigations and analytical modeling of crack growth behavior; (2) Experimental investigation of mechanical properties and performance characteristics of structural materials; (3) Environmental effect on elevated temperature mechanical behavior; and (4) Development of test techniques, upgrading, and maintenance of the AFWAL/MLLN Mechanical Test Facility. GRA

**N86-30883#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.
**ANTIMISTING FUEL RESEARCH AND DEVELOPMENT FOR COMMERCIAL AIRCRAFT Final Report**
M. YAFFEE Apr. 1986 78 p
(FAA/CT-86/7) Avail: NTIS HC A05/MF A01

This report covers the research, development, testing, and evaluation conducted by the Federal Aviation Administration (FAA) in pursuit of an effective, feasible antimisting agent for kerosene jet fuels that would prevent or reduce the dangers of postcrash, fuel mist fires. For the past eight years, most of this effort was focused on a high molecular weight polymer, FM-9 (Trademark), as a representative agent to prove the antimisting fuel concept. The results of this work indicate that the goal is achievable: Jet fuel can be modified to provide a significant degree of protection against postcrash fires in impact-survivable accidents. Additional development and testing would be required before the fuel is operationally acceptable. It would be necessary to make some modifications in fuel handling procedures and hardware in aircraft and at airports. But there appear to be no technically insurmountable problems. Author

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## ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A86-43489#**
**A SURVEY OF MULTIPLE TARGETS TRACKING TECHNIQUE**
H. ZHOU (Chinese Aeronautical Establishment, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 1-10. In Chinese, with abstract in English. refs

This paper discusses the development of multiple targets tracking techniques over the past twenty years. Attention is paid to data correlation since this is the most important and difficult aspect of multiple targets tracking. The methods of tracking a target in a repeat echoes environment are introduced, and the methods of tracking multiple targets in a repeat echoes environment are presented. Other related aspects are briefly included in the paper. Author

**A86-43495#**
**STABILITY ANALYSIS OF COMPOSITE STIFFENED LAYER PLATES UNDER COMPRESSION**
X. TONG (Aircraft Structural Strength Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 54-62. In Chinese, with abstract in English. refs

The stability of composite stiffened layer plates under axial compression is studied by analytical and finite strip element methods. Rational selection of the displacement functions is stressed and solutions are given for five different combinations of plate stiffness with load cases. By using the displacement expression chosen, the prediction of the critical stress could be performed with a computer program instead of the previous complex calculation. Therefore, it is clear in physical concept and easy to control the convergence process. A general-purpose computer program is developed for a stability analysis based on this method. Some typical cross-section configurations and composite stiffened layer plates with stiffeners have been calculated. The numerical results are in good agreement with the experimental data and the analytical solutions. Author

**A86-43496#**
**BUCKLING AND INITIAL POST BUCKLING ANALYSIS OF COMPOSITE PANELS UNDER AXIAL COMPRESSION**
J. ZHOU, T. FENG, and S. LI (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 63-70. In Chinese, with abstract in English.

The buckling and the initial post-buckling behavior of laminated composite shallow panels with orthotropic modular properties under axial compression are analyzed. The expressions for critical load and initial post-buckling parameters and the asymptotic solutions of the post-buckling state are given by solving the first two perturbation equations. As one application, the buckling and initial post-buckling behavior of long shallow panels of two different laminations cross-ply and angle-ply, are considered. Author

**A86-43502#**

**SENSITIVITY ANALYSIS OF PARAMETERS IN SOLVING INVERSE PROBLEM OF STRUCTURAL DYNAMICS**

F. GAO (Aeronautical Computation Technique Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 108-113. In Chinese, with abstract in English. refs

A sensitivity analysis of parameters in solving the inverse problem of structural dynamics is presented using the perturbation theory. By introducing a set of variable parameters in the structure, the derivatives of structural natural frequencies and/or modes with respect to these parameters are obtained so as to determine the sensitive elements or locations of the structure. In the degenerated case with multiple eigenvalues, the sensitivities of the natural frequencies are obtained by means of Puiseux series and considered as the eigenvalues of the matrix. The method is easy to implement obtaining thus the automatization of the dynamic design for the structure. It has been applied to the vibration design of several beam frame structures in aeronautical engineering and has been verified by experimental data. Author

**A86-43534#**

**AN ANALYSIS OF BENDING WAVE PROPAGATION ON IMPACT IN A ROTATING FAN BLADE**

T. SHIOYA (Tokyo, University, Japan) Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, April 1986, p. 195-198. In Japanese, with abstract in English. refs

This paper presents an theoretical analysis of the electric bending wave propagation in a rotating fan blade by the use of a simplified model. An impact of constant lateral force or constant moment is subject to a semi-infinite elastic beam at the end. Constant body force which represents the centrifugal force due to the rotation is acting parallel to the initial beam direction. The result of the analysis shows that a similar solution for the bending wave exists in case of no centrifugal force. The wave velocity and the moment are obtained in a simple form. The centrifugal force effects the decrease of the wave velocity and the amplitude of the bending moment. Author

**A86-43566*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**MODE II FATIGUE CRACK GROWTH SPECIMEN DEVELOPMENT**

R. J. BUZZARD, B. GROSS, and J. E. SRAWLEY (NASA, Lewis Research Center, Cleveland, OH) IN: Fracture mechanics; Proceedings of the Seventeenth National Symposium, Albany, NY, August 7-9, 1984 . Philadelphia, PA, American Society for Testing and Materials, 1986, p. 329-345; Discussion, p. 345, 346. Previously announced in STAR as N84-29248. refs

A Mode II test specimen was developed which has potential application in understanding phemonena associated with mixed mode fatigue failures in high performance aircraft engine bearing races. The attributes of the specimen are: it contains one single ended notch, which simplifies data gathering and reduction; the fatigue crack grows in-line with the direction of load application; a single axis test machine is sufficient to perform testing; and the Mode I component is vanishingly small. Author

**A86-43759**

**COMPUTER AIDED ENGINEERING IN STRUCTURAL DESIGN AND OPTIMIZATION**

B. FREDERIKSSON, J. BRANDT, and T. BRANA (SAAB-Scania AB, Linkoping, Sweden) IN: International FEM-Congress, 14th, Baden-Baden, West Germany, November 18, 19, 1985, Proceedings . Stuttgart, West Germany, IKOSS GmbH, 1985, p. 251, 253-266. refs

A systematic approach to the structural engineering design work is discussed. The use of the finite element internal loads models as a basis for the stress analysis and sizing work is presented. Software has been developed for automatic load and spectra generation. Local load sequences and spectra are generated based upon the result from the FE-analysis. This is then used for fatigue and fracture analysis of the structure components. In the design process it is important to find optimal solutions. Examples are minimization of structural weight or minimization of moment of inertia. Software has been developed for structural optimization. Examples on wing weight minimization and fin rudder moment of inertia minimization are discussed. Author

**A86-43784**

**DAMAGE TOLERANCE - USAF EXPERIENCE**

J. W. LINCOLN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 265-295. refs

The damage tolerance experience on U.S. Air Force aircraft is traced from the F-111 in the early seventies to the present. The phases of the damage tolerance assessment are discussed by means of examples to highlignt important aspects of the process. The experience derived from the individual assessment is used to describe the lessons learned and to illustrate the evolution of structural criteria to be used for future USAF procurements. Author

**A86-43789**

**CONTINUING STRUCTURAL INTEGRITY PROGRAM FOR TRANSPORT AIRCRAFT**

P. R. ABELKIS, M. B. HARMON, and D. S. WARREN (Douglas Aircraft Co., Long Beach, CA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 395-422. refs

Continuing structural integrity of commercial transport aircraft is provided by inspection programs established through the combined efforts of aircraft manufacturers, regulatory agencies, and aircraft operators. Criteria and guidelines have been established for the evaluation and supplementation, if necessary, of these inspection programs for older commercial transport aircraft. The evaluation is based on aircraft current usage, durability, and damage tolerance assessment of the structure using current analysis and testing technology and state-of-the-art inspection methods. A supplemental inspection program, when necessary, is based on statistical-probabilistic concepts of having and detecting damage-cracks and is implemented through a sampling program of the high-time aircraft. Author

**A86-43791**

**MAINTENANCE SYSTEM BY MEANS OF DAMAGE TOLERANCE PRINCIPLE**

K. H. GALDA (Deutsche Lufthansa AG, Hamburg, West Germany) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 473-494.

The maintenance of the structure of a civil jet transport aircraft is based on the damage tolerance principle. The inspection intervals and methods have to be determined such that a possible failure will most probably be detected before becoming critical. For new and old airplanes, the inspection system is based on the acceptable damage of the aircraft structure without a risk of a catastrophic failure. The application of the damage tolerance system includes all existing inspections geared toward more flexibility in planning and maintenance. Author

**A86-43792**

### A RATIONALE FOR THE SAFE OPERATION OF AN AIRCRAFT FLEET HAVING KNOWN CRACKS IN PRIMARY STRUCTURE

J. M. GRANDAGE (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 495-510. refs

This paper presents a rationale and procedure aimed at operating known-to-be-cracked structures at acceptable risk levels. Existing airworthiness requirements for design are referred to, and problems of applying these requirements to a fleet of cracked structures are discussed. This leads to an appropriate adaptation of the requirements. Author

**A86-43793**

### THE INFLUENCE OF SLOW GROWTH AND NET SECTION YIELDING ON THE RESIDUAL STRENGTH OF STIFFENED STRUCTURE

T. SWIFT (FAA, Long Beach, CA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 511-550. refs

In order to limit detectable crack sizes used in the damage tolerance evaluation of commercial aircraft in compliance with FAR 25.571, the regulatory authorities have been considering a further requirement that the structure be capable of 95 percent ultimate load with cracking up to detectable length. From a fracture mechanics viewpoint this is not achievable with the current materials, design concepts and working stress levels. This paper discusses the authorities' concerns together with the difficulties encountered with such a requirement. Author

**A86-43794**

### FRACTURE DIAGRAMS FOR STIFFENED AIRCRAFT STRUCTURES - EFFECTS OF MATERIAL NON-LINEARITY

M. C. LOW (British Aerospace, PLC, Aircraft Group, Bristol, England) and D. J. CARTWRIGHT (Bucknell University, Lewisburg, PA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 551-583. Research supported by British Aerospace, PLC. refs

The complex variable formulation of two-dimensional elasticity is used to analyze a crack with unequal strip yield zones in an asymmetrically stiffened sheet. The simultaneous effects of yielding in the fasteners and stiffeners are included in the analysis. The strip yield zone lengths, the crack tip opening displacements, the maximum load concentration in the stiffener and the maximum fastener force are determined for a typical aircraft stiffened panel. Fracture diagrams are constructed for the panel and are used to show the effects of panel geometry and fastener flexibility. Author

**A86-43796**

### A SIMPLE CRACK CLOSURE MODEL FOR PREDICTING FATIGUE CRACK GROWTH UNDER FLIGHT SIMULATION LOADING

D. ALIAGA, A. DAVY (Aerospatiale, Suresnes, France), and H. SCHAFF (Aerospatiale, Toulouse, France) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 605-630. refs

The model described is based on the crack closure concept. A rule which fixes changes in the opening point is used to take into account the effects of the stress ratio and the retardation effect. A conservative counting method, similar to the 'rain flow' technique, is applied to each cycle. The model therefore combines a cycle-by-cycle analysis with a conservative counting method. Other advantages of the approach are the facility with which the parameters used to represent the material can be determined, its reliability and its applicability to all metal alloys. Examples of its application to aluminum alloys and a steel are included. Author

**A86-43798**

### THE CERTIFICATION OF AIRFRAMES AND COMPONENTS IN METALS AND COMPOSITES

A. W. CARDRICK (Royal Aircraft Establishment, Airworthiness Div., Farnborough, England) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985 . Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 651-672. refs

The UK Military airworthiness authorities believe that aircraft should have a good fatigue life and tolerance to variations from the conditions used in design. The most serious variations are those which affect the entire fleet as is the case with increases in all up weight, new maneuvers, changes in stores carriage policies and wear in mechanical components. If the structure is unduly sensitive to any consequential elevated loads operational effectiveness will be impaired. A brief description is given of draft requirements for Defence Standard 00-970. It is intended that these requirements should be applied to aeroplanes and helicopters and to all structural materials including fiber composites. Author

**A86-43896**

### EXPERT SYSTEMS FOR MECHANICAL FAULT DIAGNOSIS

R. M. STEWART (Stewart Hughes, Ltd., Southampton, England) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 295-300.

The interfacing of numerically intensive, imperative programs in expert systems for mechanical fault diagnosis is examined. The design of a Machinery Management Computer for helicopters is discussed as an example of such interfacing. The fundamentals of the interfacing problem are addressed, discussing an expert system for bearing diagnostics, the interface between imperative and declarative elements, and the problem of evidence accumulation. The potential benefits and problems of artificial intelligence and expert systems in the machinery management field are considered. C.D.

**A86-43994**

### HYPERSONIC VISCOUS SHOCK LAYER ON A SURFACE WITH AN ABRUPT VARIATION OF CATALYTIC ACTIVITY

E. A. GERSHBEIN, V. IU. KAZAKOV, and V. S. SHCHELIN (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) (Teplofizika Vysokikh Temperatur, vol. 23, Sept.-Oct. 1985, p. 916-921) High Temperature (ISSN 0018-151X), vol. 23, no. 5, March 1986, p. 727-732. Translation. refs

The flow of a multicomponent mixture of nonequilibrium-reacting gases over catalytic surfaces having an inset zone of materials with different catalytic properties is investigated within the framework of the theory of a hypersonic viscous shock layer on infinite-span wings with a blunt leading edge. Author

**A86-44801**

### FLOW OF REAL FLUIDS

G. E. A. MEIER, ED. and F. OBERMEIER, ED. (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) Berlin and New York, Springer-Verlag (Lecture Notes in Physics. Volume 235), 1985, 353 p. In English and German. For individual items see A86-44802 to A86-44813.

A survey is presented of recent advances in fundamental research into numerically modelling and experimentally observing and controlling various processes of interest in fluid mehanics. Studies on the effects of the compressibility of a flow on sound propagation are reported, including work with the reverse flow theorem for transonic flow and sound generation by airfoil-vortex interaction. Sound radiation from planes and cylinders into fluids and from turbomachinery and propellers is examined. Wave momentum and power balance in a boundary layer are investigated, along with the gas dynamics, heat, adiabatic phase transitions and wavesplitting in fluids with high specific heat. Consideration is also given to acoustic turbulence, models for slender vortex breakdown, and the vortical structure of bounded turbulent shear flow. M.S.K.

**A86-44934**

### STRUCTURAL MODIFICATION BY MODAL CORRECTION

D. M. WILSON (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) Aeronautica Meridiana (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 37-42.

In the interest of achieving cost reductions in the ground testing of vibration characteristics in such large structures as those of aircraft, attention is given to alternative methods of airframe structural modification. The method of modal correction involves the addition or subtraction of pylons, fuel tanks, etc., by theoretical means, thereby reducing vibration testing requirements. Theoretically predicted results compare well with experimental data, and show that the inclusion of stiffness modification improves predictions. O.C.

**A86-45059#**

### AN ITERATIVE METHOD FOR STATICALLY INDETERMINATE STRUCTURES OF FLIGHT VEHICLE

O. MARTIN (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 31, Jan.-Feb. 1986, p. 41-46.

Using the principles of the slope deflection method and matrix calculus, an iterative method is presented which allows the reactions in the attachment points of aircraft movable surfaces, the elevator, rudder and aileron, to be determined as a function of their displacement. A deflecting supporting structure loaded with air loads is also considered, and the individual effects of the load are summed using the superposition principle. R.R.

**A86-45208**

### A SYSTEM FOR INTRODUCING MUTUAL CORRECTIONS INTO THE AIRBORNE TEMPERATURE AND AIR-SPEED METERS [SISTEMA VVEDENIIA VZAIMNYKH POPRAVOK DLIA SAMOLETNYKH IZMERITELEI TEMPERATURY I SKOROSTI VOZDUSHNYKH POTOKOV]

V. K. DMITRIEV and M. A. STRUNIN IN: Methods and technology for experimental studies of the atmosphere . Moscow, Gidrometeoizdat, 1985, p. 104-112. In Russian.

A scheme for introducing mutual corrections into the airborne thermometer and pneumoanemometer data indicating the atmospheric temperature and airspeed, as well as fluctuations in the temperature and the horizontal airspeed component, is discussed. Error estimates for several temperature and altitude values have been calculated, and the restitution coefficient for the temperature detector has been determined. The results of flight tests are presented, along with a block diagram of the system. I.S.

**A86-45231**

### A QUASI-ONE-DIMENSIONAL MODEL FOR THE EVOLUTION OF THE TURBULENT WAKE OF A BODY IN A STRATIFIED MEDIUM [KVAZIODNOMERNAIA MODEL' EVOLIUTSII V STRATIFITSIROVANNOI SREDE TURBULENTNOI OBLASTI SLEDA ZA TELOM]

L. I. SKURIN (Leningradskii Gosudarstvennyi Universitet, Leningrad, USSR) Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana (ISSN 0002-3515), vol. 22, April 1986, p. 373-379. In Russian. refs

The time dependence of the sizes of plane turbulent spots in a stratified medium is described. The plane turbulent spots are studied under conditions where the pulsation Froude number values are large and the volume increases in the region considered due to turbulent diffusion is substantial. A system of equations for the evolution of such spots in a quasi-one-dimensional approximation is derived, and conditions under which the viscous stage of evolution occurs are established. The evolution of the turbulent wake of a hypersonic vehicle is considered. I.F.

**A86-45256*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### FATIGUE LIFE ANALYSIS OF A TURBOPROP REDUCTION GEARBOX

D. G. LEWICKI, J. J. COY (NASA, Lewis Research Center; U.S Army, Propulsion Laboratory, Cleveland, OH), J. D. BLACK (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and M. SAVAGE (Akron, University, OH) ASME, Transactions, Journal of Mechanisms, Transmission, and Automation in Design, vol. 108, June 1986, p. 255-262. Previously announced in STAR as N85-27228. refs

(ASME PAPER 85-DET-10)

A fatigue life analysis of the Allison T56/501 turboprop reduction gearbox was developed. The life and reliability of the gearbox was based on the lives and reliabilities of the main power train bearings and gears. The bearing and gear lives were determined using the Lundberg-Palmgren theory and a mission profile. The five planet bearing set had the shortest calculated life among the various gearbox components, which agreed with field experience where the planet bearing had the greatest incidences of failure. The analytical predictions of relative lives among the various bearings were in reasonable agreement with field experience. The predicted gearbox life was in excellent agreement with field data when the material life adjustment factors alone were used. The gearbox had a lower predicted life in comparison with field data when no life adjustment factors were used or when lubrication life adjustment factors were used either alone or in combination with the material factors. Author

**A86-45344**

### CALCULATION OF THE EXPLOSION OF A RAPIDLY FLYING BODY [K RASCHETU VZRYVA BYSTRO LETIASHCHEGO TELA]

L. V. SHURSHALOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 26, June 1986, p. 924-933. In Russian. refs

The paper formulates the problem of the explosion of a rapidly flying body, considered as a spherical gas volume characterized by high explosion energy and a high translational velocity. An algorithm for solving the problem is proposed which, together with the conventional divergent system of gasdynamic equations, uses nondivergent equations for the kinetic and internal energy of the gas, and a difference grid moving with the exploding body. Attention is given to cases of the explosion of gas volumes moving at velocities corresponding to M = 3 and M = 30. B.J.

**A86-45422*#** Old Dominion Univ., Norfolk, Va.

### RESPONSE OF SYMMETRIC RECTANGULAR COMPOSITE LAMINATES WITH NONLINEAR DAMPING SUBJECTED TO ACOUSTIC LOADING

C. MEI (Old Dominion University, Norfolk, VA) and C. B. PRASAD AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p. refs

(Contract NAS1-17993)

(AIAA PAPER 86-1933)

Effects of both nonlinear damping and large-deflection are included in the analysis in an attempt to explain the experimental phenomena of aircraft panels excited at high sound pressure levels; that is the broadening and flattening out of the strain response peaks and the increasing of the response frequency. A nonlinear damping model is considered in the analysis using a single-mode approach. Root-mean-square (RMS) maximum deflection, RMS strains, spectral density functions of strain, and equivalent linear frequency are obtained for clamped and simply supported rectangular symmetric laminated composite plates. It is demonstrated that nonlinear damping is the one which causes the broadening of the response peaks, and it has great influence on RMS panel deflection, RMS strains, and frequency. Author

**A86-45437#**

### THE PRESSURE FIELD GENERATED BY JET-JET IMPINGEMENT

N. S. NOSSEIR and U. PELED (San Diego State University, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 7 p. refs
(Contract N00014-84-K-0373)
(AIAA PAPER 86-1951)

The impingement of two, axisymmetric turbulent jets on each other is investigated experimentally. The angle of impingement is equal to 180 deg, and the jets issue from large flat plates. Characteristics of the flowfield and pressure disturbances generated in the impinging region and amplified by feedback mechanisms are discussed. Author

**A86-45490*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

### EXPERIMENTAL INVESTIGATION OF UNSTEADY FAN FLOW INTERACTION WITH DOWNSTREAM STRUTS

W. F. NG, W. F. OBRIEN, and T. L. OLSEN (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. NASA-supported research. refs
(AIAA PAPER 86-1870)

In the present study of the unsteady pressure field produced on fan rotor blades by interaction with downstream struts, a single stage, low speed axial-flow fan was instrumented with blade-mounted high frequency pressure transducers. In addition, stationary pressure problems were used to map out the flowfield. Fluctuating pressure measurements are presented for blade midspan and 85-percent span on both the suction and pressure surfaces of the rotor blades at several positions of the downstream struts, and for two different flow coefficients. The strut is found to produce an effect on the unsteady pressure field on the rotor blades; this effect exceeds that due to the stator at design rotor-stator-strut spacing, but it rapidly declines as the struts are moved downstream. O.C.

**A86-45694**

### THE VIBRATION AND STABILITY OF SYMMETRICALLY-LAMINATED COMPOSITE RECTANGULAR PLATES SUBJECTED TO IN-PLANE STRESSES

D. J. DAWE (Birmingham, University, England) and T. J. CRAIG (VSEL Consortium, PLC, Dept. of Naval Architecture, Barrow-in-Furness, England) Composite Structures (ISSN 0263-8223), vol. 5, no. 4, 1986, p. 281-307. Research supported by the Royal Aircraft Establishment and SERC. refs

Consideration is given to the twin problems of the elastic buckling of rectangular, symmetrically-laminated composite plates and of the vibration in the presence of applied in-plane stress of such laminates. First-order shear deformation plate theory provides the mathematical model of plate behavior and the Rayleigh-Ritz and finite strip methods are used to generate numerical results for laminates of thin and moderately thick geometry, with various combinations of standard plate edge conditions. The applied stresses include uniform shear stress as well as direct stresses, and anisotropic material properties can be included. The presented results demonstrate the accuracy of the numerical methods and highlight the very significant influence that transverse shear and related thickness effects can have in the subject problems.
Author

**A86-45762**

### OPTIMIZATION OF STIFFENED PANELS UNDER COMPRESSION

W. LI (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Strain Analysis for Engineering Design (ISSN 0309-3247), vol. 21, July 1986, p. 153-158. refs

The optimization of the angle-stiffened panel under compression using the feasible direction method is studied. Only the most critical constraint could be taken into account for each iteration when using the feasible direction method, with the result that the process of calculation is greatly simplified. It is beneficial for stability and convergence of the design process that the design variables in each iteration are modified once by some experience formulae, if necessary. The illustrative examples and the comparison of the numerical results of this paper with those of another paper indicate the effectiveness and efficiency of the method presented here.

**A86-45816**

### PRECISION CASTING OF AERO GAS TURBINE COMPONENTS

G. A. WHITTAKER (G. A. Whittaker and Associates, Crewe, England) (Institute of Metals, Conference on Casting of Superalloys, London, England, Feb. 27, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, May 1986, p. 436-441.

The development of techniques for the production of aircraft gas turbine components by precision casting is described. Various steps in the casting process are discussed, including conditions of the wax and core assembly and molding practices, dewaxing, mold firing, melting practice, core removal, and the cut-off and finishing. Attention is paid to quality failures and their remedies, with special consideration given to dimensional and grain size controls; the problems of shrinkage porosity, misruns, hot tears, and surface oxidation pitting; and the causes of mechanical failures. I.S.

**A86-46135**

### FIBER OPTIC SENSORS FOR FLEXURE MEASUREMENT OF AIRCRAFT STRUCTURES

R. C. MURPHY (Canadian Marconi Co., Montreal, Canada) Unmanned Systems, vol. 4, Spring 1986, p. 31-35. refs

An evaluation is made of the possible roles that fiber-optics technologies can play in constituting an EMI-immune, low-weight structural monitoring system for very long endurance aircraft (VLEA). The key to such systems is the obviation of the fiber-optic cabling's protective material, and the direct realization of sensor devices in glass fiber structures or integrated optics devices. Attention is given to passive multiplexing techniques, lens and modulator designs, the structure of fiber-optical EM field, structural strain and deflection sensors, and the instrumentation of a VLEA's wing structure. O.C.

**A86-46148**

### NEW LEVELS OF REALISM ACHIEVED IN VISUALS FOR FLIGHT SIMULATION

M. LONG (Rediffusion Simulation, Ltd., Crawley, England) ICAO Bulletin, vol. 41, May 1986, p. 28, 29.

Novoview SP1/T and SupraWIDE are visual simulation systems for aircrew training which respectively improve image texture and furnish wrap-around imagery. Both fixed wing and rotary wing flight simulations can be implemented with these systems. SupraWIDE employs a specially designed Schmidt projection system for its CRTs which incorporates reflective rather than refractive optics. Novoview SP1/T can realistically represent actual world airports under full lighting conditions, with surrounding environmental lights and such terrain features as mountains and three-dimensional buildings. O.C.

**A86-46562**

### SUPERALLOY COMPONENT DURABILITY ENHANCEMENTS

R. A. SPRAGUE (GE Engineering Materials Technology Laboratory, Evendale, OH and Lynn, MA) and S. J. FRIESEN (General Electric Co., Evendale, OH) Journal of Metals (ISSN 0148-6608), vol. 38, July 1986, p. 24-30. refs

This overview summarizes process improvements in wrought and cast superalloy components for turbine engine applications. Techniques such as VIM, VAR, ESR and electron beam melting are discussed with respect to product cleanliness. Property enhancement is now an important consideration of forging technology. Scientists are quantifying the dependence of crack growth on microstructure and alloy design. Directional solidification casting practices that promote integrity and property enhancement are achievable through careful process control. State-of-the-art developments and future directions for the industry are also reviewed. Author

**A86-46701**

### SENSITIVITY, NOISE AND OPTICAL CROSSTALK IN HETERODYNE ACOUSTO-OPTICAL SIGNAL PROCESSORS

T. S. CHEN (TRW Electro-Optics Research Center, Redondo Beach, CA) and S. K. YAO (TRE Semiconductor Equipment Corp., Woodland Hills, CA) IN: Optical technology for microwave applications II; Proceedings of the Meeting, Arlington, VA, April 9, 10, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 88-94.

The suggestion that optical scattering in a heterodyne acoustooptical system can be ignored, in view of a beat frequency with the reference beam that lies outside the IF bandpass of the heterodyne detection, is contradicted by the present analysis. Instead, a finite point-spread function convolving with the reference beam of a heterodyne spectrum analyzer causes a mixing of photons with different frequency shifts, thereby generating IF noise. The additional contribution of a signal beam with finite scattering level to optical cross-talk, through mixing with the scattered reference beam, is presently clarified by both analytical derivation and experimental data. O.C.

**A86-46788**

### IMPACT OF SUPERCOMPUTERS ON THE NEXT DECADE OF COMPUTATIONAL FLUID DYNAMICS

E. M. MURMAN (MIT, Cambridge, MA) and S. S. ABARBANEL (Tel Aviv University, Israel) IN: Progress and supercomputing in computational fluid dynamics; Proceedings of U.S.-Israel Workshop, Jerusalem, Israel, December 1984 . Boston, MA, Birkhaeuser, 1985, p. 1-10.

The current status of computational fluid dynamics is surveyed, and future trends are projected, with an emphasis on the application of supercomputers. It is predicted that supercomputer directly addressable high-speed memory capacity will increase from 2-16 to 256 Mwords and that processor speed will increase from 100 to 1000 MFLOPS over the next 10 yrs. The implications of these improvements for the exploratory design of aircraft, for treatment of unclean aerodynamic flows, for theoretical understanding of complex flow problems, for algorithms and languages, and for subsystem development are discussed. T.K.

**A86-47011**

### INCREMENTAL AND ITERATIVE METHODS FOR SOLVING FLUID/STRUCTURE INTERACTION PROBLEMS

Y. GONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) IN: Numerical methods in laminar and turbulent flow; Proceedings of the Fourth International Conference, Swansea, Wales, July 9-12, 1985. Part 2 . Swansea, Wales, Pineridge Press, 1985, p. 1292-1300. refs

Fluid/solid coupling effects were analyzed using the finite element method as an integrated means and applying both incremental and iterative methods to solve the fluid/structure coupled equations. The incremental procedure with iteration in final steps is proposed. The proposed method was applied to solve an airflow/wing structure coupling problem, and the results were compared with those obtained by using the iterative method alone, with similar findings obtained in both procedures. I.S.

**A86-47107**

### MULTI SHAKER MODAL TESTING USING A MODIFIED TRANSIENT RANDOM EXCITATION

M. CLARK (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1 . Schenectady, NY, Union College, 1985, p. 553-557. Research supported by the Northrop Independent Research and Development Program. refs

A modal testing method which includes multishaker and transient random modal testing procedures is described. The force and response functions of the testing method are improved with digital-to-analog-converter-driver software and a modified excitation function. The method is applied to a model of a fighter aircraft being tested under transient random single and dual point excitations, true random dual point excitation, and modified transient random dual point excitation conditions. The frequency response and coherence functions are evaluated. It is noted that this method provides improvements in the transfer function and coherence. I.F.

**A86-47122**

### DETERMINING COMPONENT LOADS AND STRESSES WITH IMPROVED SYSTEM MODELING TECHNIQUES

J. W. KLAHS and G. E. TOWNLEY (Structural Dynamics Research Corp., Milford, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2 . Schenectady, NY, Union College, 1985, p. 941-948. refs

The use of static correction terms to improve the modal representation of components by accounting for the effect of truncated higher frequency modes is analytically discussed. The determination of the dynamic load field experienced by a component in a system and the resulting strains and stresses are examined. The use of modal analysis, system dynamic analysis, and finite element analysis into a very automated procedure for determining complex dynamic loads and stress/strain distributions with a high degree of confidence prior to building and testing a prototype is demonstrated. Modeling considerations and limitations are discussed, and examples are presented. C.D.

**A86-47124**

### IDENTIFICATION OF AEROELASTIC PHENOMENON EMPLOYING BISPECTRAL ANALYSIS TECHNIQUES

J.-H. CHANG, R. O. STEARMAN, D. CHOI, and E. J. POWERS (Texas, University, Austin) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2 . Schenectady, NY, Union College, 1985, p. 956-964. refs

The analytical determination of the stability features of a classical bending-torsion degree of freedom aeroelastic system is presented based on the generalized Bolotin's or harmonic balance method. It is found that the system can experience combination and/or parametric resonance phenomena when periodic time-dependent loads are induced along the chordwise dimension of the wing. These phenomena may or may not promote the occurrence of classical flutter or divergence. The advantages of this result for developing techniques in subcritical flutter testing are discussed. C.D.

**A86-47133#**

### ULTRASONIC DIRECT BACKSCATTERING TECHNIQUE FOR MATERIAL SURFACE INSPECTION

E. J. CHERN and G. P. EGAN (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) IN: Symposium on Nondestructive Evaluation, 15th, San Antonio, TX, April 23-25, 1985, Proceedings . San Antonio, TX, Nondestructive Testing Information Analysis Center, 1986, p. 82-88. refs

The experimental results obtained from low cycle fatigue (LCF) surface cracks using the ultrasonic direct backscattering satellite pulse measurements and frequency domain analysis are reported. The specimens examined were an Inconel 718 flat plate with three surface-connected LCE cracks and a DA 718 plate with six cracks of various sizes. The ulrasonic transducer used in the experiment was a 5 MHz broadband longitudinal transducer with a 6-in. focal length. The angle of incidence was varied from 0 to 40 deg incrementally in steps of 10 deg. The experimental results showed improved detectability of fatigue cracks at 20 deg oblique angle of incidence. The defect sizes were estimated based on the satellite pulse delay time and frequency resonance pattern. The ultrasonic results were compared with the metallographic measurements and are in good agreement. The technique can be used to eliminate the inspection dead zone of normal longitudinal inspections. Author

**N86-29827#** Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).

**PRESSURE DROP AND HEAT TRANSFER CHARACTERISTICS OF CIRCULAR AND OBLONG LOW ASPECT RATIO PIN FINS**

S. C. ARORA and W. A. MESSEH *In* AGARD Heat Transfer and Cooling in Gas Turbines 15 p Sep. 1985

Avail: NTIS HC A23/MF A01

The pressure drop and heat transfer characteristics of circular and oblong pin fins of height-to-diameter ratio of unity used to augment internal cooling of gas turbine airfoils are presented. Data were obtained for an array of 10 rows of staggered pin fins in a 25:1 aspect ratio channel, with both pins and channel endwalls forming the heat transfer surface. Results show that the array average friction factor increases with increasing blockage caused by different arrangement of pin fin geometries in the channel. The local heat transfer coefficient increases up to the 3rd row of pin fins and decreases thereafter. Oblong pin fins with gamma=90 deg (major axis parallel to the direction of flow) result in higher heat transfer rates and lower friction factor than the circular pin fins. For other orientations, oblong pin fins do not offer any advantage over circular pin fins for Re or = 20,000 (typical of small gas turbine engines). M.G.

**N86-29830#** Oxford Univ. (England). Dept. of Engineering Science.

**WAKE-PASSING IN A TURBINE ROTOR CASCADE**

D. J. DOORLY, M. L. G. OLDFIELD, and C. T. J. SCRIVENER (Rolls-Royce Ltd., Derby, England) *In* AGARD Heat Transfer and Cooling in Gas Turbines 18 p Sep. 1985

Avail: NTIS HC A23/MF A01

A technique for generating realistic wakes upstream of a stationary turbine blade cascade at full scale Mach numbers and Reynolds numbers is described. High speed Schlieren photographs showing the development of the wake flow through the cascade are presented, together with unique high speed measurements of the fluctuations of the surface heat transfer rate as the nozzle guide vane (NGV) wakes pass over the rotor blade surface. Combining the flow visualization results with the unsteady heat transfer measurements reveals the radically different nature of the boundary layer transition caused by wake passing; an understanding of which will be essential for the development of improved prediction techniques. M.G.

**N86-29840#** Purdue Univ., West Lafayette, Ind. School of Mechanical Engineering.

**A MODEL FOR CORRELATING FLAT PLATE FILM COOLING EFFECTIVENESS FOR ROWS OF ROUND HOLES**

M. R. LECUYER and F. O. SOECHTING (Pratt and Whitney Aircraft, West Palm Beach, Fla.) *In* AGARD Heat Transfer and Cooling in Gas Turbines 12 p Sep. 1985

Avail: NTIS HC A23/MF A01

An effective method of cooling, that has found widespread application in aircraft gas turbines, is the injection of a film of cooling air through holes into the hot mainstream gas to provide a buffer layer between the hot gas and the airfoil surface. Film cooling has been extensively investigated and the results have been reported in the literature. However, there is no generalized method reported in the literature to predict the film cooling performance as influenced by the major variables. A generalized film cooling correlation has been developed, utilizing data reported in the literature, for constant velocity and flat plate boundary layer development. This work provides a basic understanding of the complex interaction of the major variables effecting film cooling performance. Author

**N86-29847#** Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France). Centre de Villaroche

**COOLING TECHNIQUES FOR TURBOJET PRE-HEATER CHANNELS [TECHNIQUES DE FROIDISSEMENT DES CANAUX DE RECHAUFFE DES TURBOREACTEURS]**

M. DESAULTY, P. TROULLOT, and S. COUTOR *In* AGARD Heat Transfer and Cooling in Gas Turbines 11 p Sep. 1985 In FRENCH

Avail: NTIS HC A23/MF A01

Increases in the performance of turbojets with pre-heating are dependent upon technological research in the area of protection of the wall in pre-heater channels. The procedures used to cool the thermal protection jackets have undergone important improvements which have optimized performance, reduced weight and improved cooling efficiency. This report presents a comparison of the thermal protection jackets for several SNECMA engines, as well as the principal stages of development for the jacket from the design stages through static engines tests. M.G.

**N86-29856#** Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

**TRANSIENT THERMAL BEHAVIOUR OF A COMPRESSOR ROTOR WITH VENTILATION: TEST RESULTS UNDER SIMULATED ENGINE CONDITIONS**

E. REILE, U. RADONS, and D. K. HENNECKE *In* AGARD Heat Transfer and Cooling in Gas Turbines 9 p Sep. 1985

Avail: NTIS HC A23/MF A01

The development of advanced compressors for modern aero-engines requires detailed knowledge of the transient thermal behavior of the rotor disks to enable accurate prediction of rotor life and, additionally, of the thermal growth of the rotor for the evaluation of tip clearances. In the quest for longer life and higher reliability of the parts as well as reduced clearances even at transient conditions, the designer has to be able to influence the thermal behavior of the rotor. A very effective way is to vent small amounts of air through the rotor cavities. The design of such a vented rotor is presented. The main emphasis is placed on a detailed description of a test rig specially built for this purpose. The testing was carried out under simulated engine conditions for a wide range of parameters. The results are compared with those obtained with a theoretical model derived from fundamental tests at the University of Sussex, where heat transfer in rotating cavities is investigated. Good agreement is observed. Some final tests were done in an engine. The results also exhibit good agreement with the rig results under simulated conditions, when the proper dimensionless parameters are considered, providing the validity of the simulation. Author

**N86-29857#** Instituto Superior Tecnico, Lisbon (Portugal). Dept. of Mechanical Engineering.

**HEAT EXCHANGERS IN REGENERATIVE GAS TURBINE CYCLES**

M. N. R. NINA and M. P. N. AGUAS *In* AGARD Heat Transfer and Cooling in Gas Turbines 8 p Sep. 1985

Avail: NTIS HC A23/MF A01

Advances in compact heat exchanger design and fabrication together with fuel cost rises continuously improve the attractability of regenerative gas turbine helicopter engines. In this study cycle parameters aiming at reduced specific fuel consumption and increased payload or mission range, have been optimized together with heat exchanger type and size. The discussion is based on a typical mission for an attack helicopter in the 900 kw power class. A range of heat exchangers is studied to define the most favorable geometry in terms of lower fuel consumption and minimum engine plus fuel weight. Heat exchanger volume, frontal area ratio and pressure drop effect on cycle efficiency are considered. Author

**N86-29858#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

**CERAMIC HEAT EXCHANGERS FOR GAS TURBINES OR TURBOJET ENGINES**

S. BOUDIGUES and J. FABRI *In* AGARD Heat Transfer and Cooling in Gas Turbines 14 p Sep. 1985 In FRENCH; ENGLISH summary

Avail: NTIS HC A23/MF A01

Heat exchangers made of steel and placed downstream of the last turbine of a turbojet engine or any gas turbine are too heavy and too cumbersome. With a heat exchanger made of silicon carbide mass, performance, volume and cost balances which greatly benefit civilian or military use can be obtained. Silicon carbide has good thermal performance and makes it possible to situate the heat exchanger between turbine stages. Both the pressure of cold and hot gases are thus increased, the heat exchange processes are amplified, the length and the diameter of the exchanger are reduced. With the density of this material being only 3.2, the overall mass of the exchanger is considerably reduced. It is also possible to shortcut part of the cold air, and thus obtain a controlling parameter. A kind of after burner effect is obtained, although a single combustor is used, and the corresponding thermodynamic process has a higher efficiency than the after burning process. Author

**N86-29859#** Technische Univ., Aachen (West Germany). Inst. for Jet Propulsion and Turbomachinery.

**EFFECT OF FILM COOLING ON THE AERODYNAMIC PERFORMANCE OF A TURBINE CASCADE**

O KOELLEN and W. KOSCHEL *In* AGARD Heat Transfer and Cooling in Gas Turbines 16 p Sep. 1985

Avail: NTIS HCA23/MF A01

The aerodynamic performance of a film cooled turbine cascade for a typical design with multiple rows of cooling holes was investigated in an annular cascade rig with air at room temperature. The work was concentrated on the individual effect of the injection row position on the aerodynamic cascade losses and on the downstream flow field. For six different single row configurations the tests were conducted in a wide range of varying coolant mass flow rates and main stream Mach numbers. Typical results of these measurements are presented and discussed. Three models for the aerodynamic loss prediction based on different theoretical approaches, which are known from literature, were examined and improved. The presented two mixing layer models take into account the penetration of the injected cooling air into the main stream, whereas the third model predicts flow losses by a boundary layer calculation with film cooling air injection. Some tests with flow visualization by Schlieren photography were carried out showing the mixing effects of the injected coolant flow. Finally results of the predicted performance are compared with the experimental data. M.G.

**N86-29861#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Experimentelle Stroemungsmechanik.

**AERODYNAMIC EFFECT OF COOLANT EJECTION IN THE REAR PART OF TRANSONIC ROTOR BLADES**

F. H. KOST and A. T. HOLMES (Rolls-Royce Ltd., Bristol, England) *In* AGARD Heat transfer and Cooling in Gas Turbines 12 p Sep. 1985

Avail: NTIS HC A23/MF A01

An investigation of transonic turbine blades designed by Rolls-Royce/Bristol concerning the aerodynamic penalties of coolant flow for two alternative cooling configurations is discussed. Rolls-Royce designed a blade with a thick trailing edge where the coolant is ejected through slots in the trailing edge and a second blade with a thin trailing edge where coolant is ejected through a row of holes on the pressure side and a row of holes on the suction side. Tests were performed in a plane cascade wind tunnel. The results indicate the sensitivity of the blade performance to cooling configuration and coolant flow rate. By combining measured data from blade surface and wake traverses it was possible to separate the various loss mechanisms. Therefore, the separate losses due to the momentum of the coolant, change of base pressure, and change of blade friction could be determined quantitatively as a function of coolant flow rate. M.G.

**N86-30090*#** Nevada Univ., Reno. Engineering Research and Development Center.

**COMPUTATIONS AND TURBULENT FLOW MODELING IN SUPPORT OF HELICOPTER ROTOR TECHNOLOGY Final Report, 1 Jun. 1984 - 30 Nov. 1985**

W. C. ROSE Nov. 1985 53 p

(Contract NSG-2291)

(NASA-CR-177095; NAS 1.26:177095) Avail: NTIS HC A04/MF A01 CSCL 20D

The angle of attack (AOA) tandem cavity wind tunnel experiment was prepared. Actual wind tunnel testing started shortly after the beginning of 1985. A multi-probe aerodynamic rake was designed and installed for use in surveying the shear layers present over the open cavity on the Kuiper Airborne Observatory (KAO). The nature of the behavior of the thermal environment within the KAO cavity at operational altitudes was determined. Assistance was given in the design of the cavity for the University of Denver radiometer. Attempts to distinguish between the optical terms of blur circle size (or image size) and the term due to jitter were discussed. B.G.

**N86-30094*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.

**EXPERIMENTAL RESULTS OF THE CONTROL OF A VORTICAL FLOW BY TANGENTIAL BLOWING**

N. J. WOOD and L. ROBERTS May 1986 73 p Sponsored by NASA

(NASA-CR-176932; NAS 1.26:176932; JIAA-TR-71) Avail: NTIS HC A04/MF A01 CSCL 20D

The results of a wind tunnel test to investigate the controlling effects of tangential, leading edge blowing on the vortical flow over a delta wing are given. Blowing is used to directly control the crossflow separation points at the rounded leading edge and hence, the trajectory of the feeding sheet and the location of the vortex. Experiments were conducted for both co-flowing and counter-flowing configurations over a range of angles of attack from 0 to 90 degrees. Results in the form of pressure distributions, overall force coefficients and flow mappings were obtained. The emphasis is on data presentation rather than detailed analysis. The initial results indicate that the co-flowing configuration was capable of extending the regime of stable, controlled vortical flow over the upper surface by approximately 30 degrees angle of attack for modest blowing requirements. Increases in maximum normal force coefficient of approximately 30% were achieved and significant rolling moments produced at angles of attack from 30 to 60 degrees. The counter-flowing configuration indicated only minor lift augmentation with the exception of an isolated occurrence at 20 degrees angle of attack. At that condition, with very weak blowing, a lift augmentation of approximately 20 was measured.

**N86-30126#** Air Force Academy, Colo. Research Lab.

**ADVANCED LASER BASED INERTIAL INSTRUMENT DEVELOPMENT Final Report, Jan. 1984 - Mar. 1986**

J. R. ROTGE 1986 18 p

(AD-A166307; FJSRL-TR-86-0001) Avail: NTIS HC A02/MF A01 CSCL 17G

Active laser gyroscopes suffer from a lock-in phenomenon, a result of backscatter from the cavity optical elements, which limit their performance in the regime of near-zero rotation. The flip-flop gyro proposed and initially investigated under this effort shows potential for minimizing or avoiding this lock-in effect. The need for a high accuracy, inexpensive and reliable clock, suitable for avionics applications was the motivation for the laser clock proposed and studied during the course of this effort. Both devices require and deserve further investigation to properly demonstrate their utility. GRA

**N86-30219#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Struct

**PRELIMINARY INSTRUMENTATION FOR AEROELASTIC TESTS AT THE COMPRESSOR LEVEL Final Report [INSTRUMENTATION PRELIMINAIRE AUX ESSAIS AEROELASTIQUES AU BANC COMPRESSEUR]**

I. CAFARELLI Dec. 1985 15 p In FRENCH
(Contract SNECMA-265.806-VY)
(ONERA-RT-95/7108-RY-054-R; ESA-86-97274) Avail: NTIS HC A02/MF A01

Unsteady pressure characterization methods are presented. The instrumentation of the blades before being assembled is described, including the unsteady sensors and an interface printed circuit. The assembling procedures and supplementary precautions such as protective painting are also discussed. ESA

**N86-30233*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**TECHNIQUE FOR MEASURING SIDE FORCES ON A BANKED AIRCRAFT WITH A FREE-SWIVELING NOSE GEAR**

S. M. STUBBS and J. A. TANNER Aug. 1986 23 p
(NASA-TM-87719; L-16137; NAS 1.15:87719) Avail: NTIS HC A02/MF A01 CSCL 20K

An experimental investigation was conducted at the Langley Research Center to determine a method for towing an aircraft to measure the side forces of a free-swiveling nose gear due to variations in bank angle. A F-106 aircraft and the Space Shuttle orbiter OV-101 were towed to measure side forces on full-size aircraft for bank angles up to 3 deg. These tests indicate that substantial side forces will occur if an aircraft is rolling on a runway in a banked attitude even when the nose gear is free to swivel. Corotation of a twin-tire nose gear appears to cause a substantial increase in side force due to bank angle compared with a nose gear with indepdendently rotating wheels. Author

**N86-30641#** Israel Aircraft Industries Ltd., Ben-Gurion Airport.

**STATIC AEROELASTIC ANALYSIS USING AIRCRAFT VIBRATION MODES**

Z. SHEENA and M. KARPEL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 229-232 1985
Avail: NTIS HC A99/MF E03

A method for the calculation of the airload distribution and aeroelastic effectiveness parameters of a flexible aircraft from the distribution of a rigid one, using its vibration modes, is presented. The method uses modal data of the model in the form of a limited number of low frequency mode shapes and their associated generalized stiffnesses. The mathematical operations are done on the generalized matrices of the model which have a small number of degrees of freedom. The method can calculate the static aeroelastic properties of a free-free aircraft using its elastic, inertial, and aerodynamic properties. The method is suitable for making parametric analyses involving changes in the stiffness of the structure and the aerodynamics of the model. Numerical examples are given and the convergence with the number of modes taken into account is discussed. ESA

**N86-30646#** Pilatus Aircraft Ltd., Stans (Switzerland).

**EXPERIENCE WITH AEROELASTIC ANALYSIS OF A SINGLE ENGINE TURBO TRAINER USING FINITE ELEMENT METHODS**

M. J. REINICKE, A. S. TURI (Omega G.m.b.H., Immenstaad West Germany), and A. VOLLAN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 286-296 1985
Avail: NTIS HC A99/MF E03

The PC-9 trainer aircraft dynamic analysis concept, based on a theoretical approach relying upon results of extensive ground vibration tests conducted on the similar structure of the PC-7, is outlined. The mathematical model shows good agreement with test results. Flight flutter tests verify the calculated aeroelastic stability. The program dealing with modal variation of mass, stiffness and damping allows changes on superelement level. Hence, the size of the residual structure can be further reduced and the CPU time cut down accordingly. ESA

**N86-30669#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. of Aeroelasticity.

**ADVANCES IN GROUND VIBRATION TESTING USING A COMBINATION OF PHASE RESONANCE AND PHASE SEPARATION METHODS**

N. NIEDBAL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 523-528 1985
Avail: NTIS HC A99/MF E03

A ground vibration test (GVT) method that uses the complex response modes obtained directly from harmonic excitation near resonance with the arbitrary force distribution to set up the generalized dynamic equation of motion without knowledge of normal modes and normal mode parameter was derived. The dominating quantities of the method are the response mode matrices and the characteristic matrices which may be compared with the generalized mass and stiffness matrices of the phase resonance method. It is demonstrated how to derive normal mode shapes and associated normal mode parameters from the information contained in the characteristic matrices and in the response mode matrices. The method was validated by applying it to the solution of a flutter problem and the evaluation of normal mode parameters. Data were obtained from a GVT performed on a full-scale aircraft. ESA

**N86-30781#** Strathclyde Univ., Glasgow (Scotland). Dept. of Mechanics of Materials.

**ASSESSING THE EFFECTS OF DELAMINATIONS ON THE POSTBUCKLING STRENGTH OF CRFP PANELS**

W. M. BANKS, J. RHODES, and G. B. CHAI *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 197-202 Feb. 1986 Sponsored by UK Ministry of Defense and ESA
Avail: NTIS HC A16/MF A01

The effect of deliberately inbuilt delaminations on the postbuckling strength of carbon fiber composite panels with a b/t ratio of 70 and 50 was tested. The panels are fabricated from 14 layers of unidirectional carbon fiber using an autoclave process. The delamination positions were chosen to coincide with the position of highest interlaminar shear stress, the position of highest direct strain, the central buckle peak, and the inflection points on the panel. The control panel for a b/t ratio of 68.57 failed prematurely due to unforeseen edge effects. However it is clear that the worst position for delamination is when it coincides with the highest interlaminar shear stress at the edge of the panel. There appears to be little effect with the delamination at the buckle peak. ESA

**N86-30890#** New Mexico Univ., Albuquerque. Engineering Research Inst.

**FIRE EXTINGUISHING AGENTS FOR OXYGEN-ENRICHED ATMOSPHERES Final Report, 1 Apr. 1982 - 30 Nov. 1985**

M. A. PLUGGE, C. W. WILSON, D. M. ZALLEN, and J. L. WALKER Dec. 1985 98 p
(Contract F29601-81-C-0013)
(AD-A166967; NMERI-TA3-19; ESL-TR-85-26) Avail: NTIS HC A05/MF A01 CSCL 13L

Fire-suppression agent requirements for extinguishing fires in oxygen-enriched atmospheres were determined employing small-, medium-, large-, and full-scale test apparatuses. The small- and medium-scale tests showed that a doubling of the oxygen concentration required five times more HALON for extinguishment. For fires of similar size and intensity, the effect of oxygen enrichment of the diluent volume in the HC-131A was not as grate as in the smaller compartments of the B-52 which presented a higher damage scenario. The full-scale tests showed that damage to the airframe was as important a factor in extinguishment as oxygen enrichment. GRA

**N86-30898#** Selenia Industrie Associate S.p.A., Rome (Italy). Engineering Support Dept.

**AN EXAMPLE OF INTEGRATED LOGISTIC SUPPORT APPLIED ALSO TO PRODUCTION TESTING**

V. BUONTEMPO *In its* Rivista Tecnica Selenia, v. 9, no. 4, p 26-45 1985

Avail: NTIS HC A03/MF A01

The basic concepts of an aerospace industry integrated logistic support plan are presented. An example shows that as well as achieving overall economy on system life cycle support cost, it reduces production costs by designing support means and production test in harmony with the logistic support means. A life cycle computation model related to the logistic support is provided. The model is also applicable to on board avionic systems such as Tornado and AMX aircraft and EH 101 helicopter. ESA

**N86-30907#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

**A MODIFICATION OF THE H-133 GROUND COMMUNICATIONS HEADSET FOR USE IN INTENSE NOISE ENVIRONMENTS**

C. W. NIXON and H. C. SOMMER 7 Mar. 1986 31 p

(AD-A166981; AAMRL-TR-86-009) Avail: NTIS HC A03/MF A01 CSCL 17B

Detailed technical information and instructions are provided for a simple modification of the Air Force standard H-133 ground communications headset for use in intense noise environments at levels of 135 db (SPL) and higher. This modification involves the replacement of the conventional H-136 earphone with a miniaturized receiver mounted on a custom molded insert earplug. An adaptor box-line potentiometer is fabricated to provide manual control of the level of the speech signal at the ear of the wearer. The modified H-133 communications headset has been utilized at selected Air Force bases by ground maintenance personnel who rate the hearing protection and voice communications performance as excellent. GRA

**N86-30908#** Mitre Corp., Bedford, Mass.

**MONOPOLE ELEMENT AT THE CENTER OF A CIRCULAR GROUNDPLANE OF ARBITRARY RADIUS. VOLUME 1: THEORY AND RESULTS Final Report**

M. M. WEINER, S. P. CRUZE, C. C. LI, and W. J. WILSON Mar. 1986 136 p

(Contract F19628-84-C-0001)

(AD-A166991; MTR-9622-VOL-1) Avail: NTIS HC A07/MF A01 CSCL 20N

The Air Force SINCGARS VHF-FM radio is a frequency-hopping anti-jam device utilizing electrically short antenna to minimize aerodynamic drag on airborne platforms. The development of optimally efficient, electronically tuneable antennas for this radio is of interest. Although the antenna groundplane is platform-dependent, it is usually small compared to an rf wavelength. A circular groundplane provides a standardized geometry with which to model and evaluate candidate antennas. Accordingly, a VHF antenna range with an 8 ft. diameter circular groundplane has been constructed to evaluate candidate antennas. The electrical properties of a monopole element at the center of a circular groundplane of finite radius are of interest to this program for (1) qualifying the antenna range; (2) establishing antenna standards with which to measure test antennas; and (3) modeling candidate antennas. A survey of the literature revealed that although this antenna has the simplest geometry of any monopole antenna, its properties are neither well understood nor standardized, particularly for groundplane radii which are small or comparable to a wavelength. This paper attempts to address this deficiency. Author (GRA)

**N86-30931#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**DETERMINATION OF ANTENNAE PATTERNS AND RADAR REFLECTION CHARACTERISTICS OF AIRCRAFT**

H. BOTHE, D. MACDONALD, and A. POOL, ed. May 1986 138 p

(AGARD-AG-300-VOL-4; ISBN92-835-1530-7) Avail: NTIS HC A07/MF A01

The different types of aircraft antennas, their radiation characteristics and their preferred siting on the airframe are described. Emphasis is placed on the various methods for determining aircraft antenna radiation patterns (ARP) and advantages, disadvantages and limitations of each method are indicated. Mathematical modelling, model measurements and in-flight measurements in conjunction with the applied flight test techniques are included. Examples of practical results are given. Methods of determining aircraft radar characteristics are also described, indicating advantages, disadvantages and limitations of each method. Relevant fundamentals of radar theory are included only as necessary to appreciation of the real meaning of radar cross section (RCS) and angular glint. The measuring methods included are dynamic full-scale, static full-scale, sub-scale optical, ultrasonic and radio modelling. References are made to RCS measuring facilities in the USA and Europe and the UK Radio Modelling Facility is used extensively to exemplify the sub scale technique. Author

**N86-30988#** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

**NUMERICAL TECHNIQUES FOR VISCOUS FLOW CALCULATIONS IN TURBOMACHINERY BLADINGS**

1986 516 p Lecture Series held in Rhode-Saint-Genese, Belgium, 20-24 Jan. 1986

(VKI-LS-1986-02; ESA-86-97482) Avail: NTIS HC A22/MF A01

Governing equations and solution methods of Navier-Stokes equations; numerical modeling of Navier-Stokes equations; turbulence models; grid generation systems in turbomachinery; Navier-Stokes computations for circulation controlled airfoils and exotic airfoils; multigrid convergence acceleration techniques for explicit Euler solvers and applications to Navier-Stokes calculations; and application of full Navier-Stokes solvers to turbomachinery flow problems were discussed.

ESA

**N86-30995#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NAVIER-STOKES COMPUTATIONS FOR CIRCULATION CONTROLLED AIRFOILS**

T. H. PULLIAM, D. C. JESPEREN, and T. J. BARTH *In* Von Karman Inst. for Fluid Dynamics Numerical Techniques for Viscous Flow Calculations in Turbomachinery Bladings 18 p 1986 Presented at 18th AIAA Fluid Dynamics and Plasmadynamics and Lasers Conference, Cincinnati, Ohio, 16-18 Jul. 1985

(AIAA-85-1587) Avail: NTIS HC A22/MF A01

Navier-Stokes computations of subsonic to transonic flow past airfoils with augmented lift due to rearward jet blowing over a curved trailing edge are presented. The approach uses a spiral grid topology. Solutions are obtained using a Navier-Stokes code which employs an implicit finite difference method, an algebraic turbulence model, and developments which improve stability, convergence, and accuracy. Results are compared against experiments for no jet blowing and moderate jet pressures and demonstrate the capability to compute these complicated flows.

ESA

**N86-30996#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
**NAVIER-STOKES COMPUTATIONS FOR EXOTIC AIRFOILS**
T. J. BARTH (Informatics General Corp., Palo Alto, Calif.), T. H. PULLIAM, and P. G. BUNING *In* Von Karman Inst. for Fluid Dynamics Numerical Techniques for Viscous Flow Calculations in Turbomachinery Bladings 17 p 1986 Presented at 23rd AIAA Aerospace Science Meeting, Reno, Nev., 14-17 Jan. 1985
(AIAA-85-0109) Avail: NTIS HC A22/MF A01

A hyperbolic grid generator with improvements for handling sharp corners and concave surfaces combined with a Navier-Stokes flow solver is applied to complex two dimensional airfoil configurations. Steady separated flow about an iced leading edge of an airfoil is presented. Unsteady viscous separated flows past an airfoil at two angles of attack with a spoiler deployed at 60 deg are compared with experiment. The spoiler computations are performed with two different topological maps of the physical domain to the computational domain. Graphical techniques for the static and unsteady display of the flow fields are discussed. ESA

**N86-30999*#** Aeronautical Research Associates of Princeton, Inc., N. J.
**A FUNDAMENTAL STUDY OF DRAG AND AN ASSESSMENT OF CONVENTIONAL DRAG-DUE-TO-LIFT REDUCTION DEVICES**
J. E. YATES and C. D. DONALD Washington NASA Sep. 1986 34 p
(Contract NAS1-18065)
(NASA-CR-4004; NAS 1.26:4004; ARAP-577) Avail: NTIS HC A03/MF A01 CSCL 20D

The integral conservation laws of fluid mechanics are used to assess the drag efficiency of lifting wings, both CTOL and various out-of-plane configurations. The drag-due-to-lift is separated into two major components: (1) the induced drag-due-to-lift that depends on aspect ratio but is relatively independent of Reynolds number; (2) the form drag-due-to-lift that is independent of aspect ratio but dependent on the details of the wing section design, planform and Reynolds number. For each lifting configuration there is an optimal load distribution that yields the minimum value of drag-due-to-lift. For well designed high aspect ratio CTOL wings the two drag components are independent. With modern design technology CTOL wings can be (and usually are) designed with a drag-due-to-lift efficiency close to unity. Wing tip-devices (winglets, feathers, sails, etc.) can improve drag-due-to-lift efficiency by 10 to 15% if they are designed as an integral part of the wing. As add-on devices they can be detrimental. It is estimated that 25% improvements of wing drag-due-to-lift efficiency can be obtained with joined tip configurations and vertically separated lifting elements without considering additional benefits that might be realized by improved structural efficiency. It is strongly recommended that an integrated aerodynamic/structural approach be taken in the design of (or research on) future out-of-plane configurations. Author

**N86-31010#** Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
**THREE-DIMENSIONAL SHOCK WAVE AND TURBULENT BOUNDARY LAYER INTERACTIONS Final Report, 1 Aug. 1981 - 31 Jul. 1984**
S. M. BOGDONOFF Sep. 1985 75 p
(Contract F49620-81-K-0018)
(AD-A167086; REPT-1723-MAE; AFOSR-85-1242TR) Avail: NTIS HC A04/MF A01 CSCL 20D

An extensive experimental study of three-dimensional shock wave turbulent boundary layer interactions caused by shock generators defined solely by angles has been carried out at Mach 3. Sharp fins, sharp swept fins, swept wedges, and semi-cones have been used to generate a wide range of shock waves. The interaction of these waves with turbulent boundary layers has been investigated by surface flow visualization, mean surface static pressure distributions, flowfield surveys of total pressure and yaw, and several flowfield visualization techniques. Some exploratory high frequency surface pressure measurements have been carried out to evaluate the steadiness of these interactions. Scaling laws for both surface and flowfield features have been derived. Some limited studies were carried out at a Mach number of 2. A flowfield study has shown that the initial part of interactions caused by the same strength and geometrical shock wave generated by different shock generators are all similar. The footprints of the interactions, as shown by surface flow visualization, can be categorized as approximately conical or cylindrical, and the boundaries between these two regions have been defined for both Mach 3 and Mach 2. There are still questions with regards to the detailed flowfield structures and physical mechanisms, but the three-dimensional interactions appeared to be less unsteady than that of two-dimensional separated flows. GRA

**N86-31030*#** General Electric Co., Wilmington, Mass. Aircraft Instruments Dept.
**HIGH ACCURACY FUEL FLOWMETER Final Report**
1986 346 p
(Contract NAS3-22139)
(NASA-CR-174869; NAS 1.26:174869) Avail: NTIS HC A15/MF A01 CSCL 14B

All three flowmeter concepts (vortex, dual turbine, and angular momentum) were subjected to experimental and analytical investigation to determine the potential portotype performance. The three concepts were subjected to a comprehensive rating. Eight parameters of performance were evaluated on a zero-to-ten scale, weighted, and summed. The relative ratings of the vortex, dual turbine, and angular momentum flowmeters are 0.71, 1.00, and 0.95, respectively. The dual turbine flowmeter concept was selected as the primary candidate and the angular momentum flowmeter as the secondary candidate for prototype development and evaluation. B.G.

**N86-31070*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**AEROELASTIC CONSIDERATIONS FOR TORSIONALLY SOFT ROTORS**
W. R. MANTAY and W. T. YEAGER, JR. Aug. 1986 20 p Presented at the AHS 2nd Decennial Specialists' Meeting on Rotorcraft Dynamics, Moffett Field, Calif., 7-9 Nov. 1984
(NASA-TM-87687; NAS 1.15:87687; USAAVSCOM-TR-86-B-1) Avail: NTIS HC A02/MF A01 CSCL 20K

A research study was initiated to systematically determine the impact of selected blade tip geometric parameters on conformable rotor performance and loads characteristics. The model articulated rotors included baseline and torsionally soft blades with interchangeable tips. Seven blade tip designs were evaluated on the baseline rotor and six tip designs were tested on the torsionally soft blades. The designs incorporated a systemmatic variation in geometric parameters including sweep, taper, and anhedral. The rotors were evaluated in the NASA Langley Transonic Dynamics Tunnel at several advance ratios, lift and propulsive force values, and tip Mach numbers. A track sensitivity study was also conducted at several advance ratios for both rotors. Based on the test results, tip parameter variations generated significant rotor performance and loads differences for both baseline and torsionally soft blades. Azimuthal variation of elastic twist generated by variations in the tip parameters strongly correlated with rotor performance and loads, but the magnitude of advancing blade elastic twist did not. In addition, fixed system vibratory loads and rotor track for potential conformable rotor candidates appears very sensitive to parametric rotor changes. Author

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## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-44150#**

**DYNAMIC STALL - THE CASE OF THE VERTICAL AXIS WIND TURBINE**

A. LANEVILLE and P. VITTECOQ (Sherbrooke, Univesite, Canada) ASME, Transactions, Journal of Solar Energy Engineering (ISSN 0199-6231), vol. 108, May 1986, p. 140-145. IREG-NSERC-supported research. refs

This paper presents the results of an experimental investigation on a driven Darrieus turbine rotating at different tip speed ratios. For a Reynolds number of 3.8 x 10 to the 4th, the results indicate the presence of dynamic stall at tip speed ratio less than 4, and that helicopter blade aerodynamics can be used in order to explain some aspects of the phenomenon. It was observed that in deep stall conditions, a vortex is formed at the leading edge; this vortex moves over the airfoil surface with 1/3 of the airfoil speed and then is shed at the trailing edge. After its shedding, the vortex can interact with the airfoil surface as the blade passes downstream. Author

**A86-44380**

**FORECASTING FOR CIVIL AVIATION. II**

L. DENT (Meteorological Office, Bracknell, England) Weather (ISSN 0043-1656), vol. 41, March 1986, p. 82-89.

The distinguishing features of long-haul intercontinental flights, short-haul continental flights and general aviation (transporting of business executives, etc.) are outlined and examples of flight documentation are provided. It is noted that the two primary concerns for both pilot and forecaster are air safety and economics. While the former requires constant vigilance on the part of aircrews, ground crews, meteorological observers and forecasters, the latter requires careful calculation of just how much fuel is needed for a flight. In effect, route winds and temperatures must be determined with great accuracy. K.K.

**A86-46138**

**LLWAS - AN INTEGRAL PART OF THE U.S. WIND-SHEAR SAFETY PROGRAMME**

C. B. BAKER, D. W. GILMORE, and R. MCCALL (Climatronics Corp., Bohemia, NY) ICAO Bulletin, vol. 41, March 1986, p. 11-13.

The use of the low level wind shear alert system (LLWAS) to detect wind shear and provide warnings for aircraft is examined. Wind shear alters lift forces and causes abrupt changes in wind direction and velocity within a very small area and for a short period of time. Wind shear is either vertical or horizontal and is classified into micro, meso, and synoptic scale groups. The effects of micro-and macro-mesoscale wind shear on aircraft are described. The LLWAS consists of an array of wind sensors composed of a center-field unit and five outlying remote stations; the system provides continuous display of wind data to the air traffic control tower. Modifications to the system, such as improving the gust direction algorithm, the display, and the speed and accuracy of the ground/pilot communications, are studied. The need to train pilots and ground personnel for recognition avoidance and reaction to wind-shear events is discussed. The development of a wind shear detection system that combines the capabilities of the LLWAS and Doppler detection systems is proposed. I.F.

**N86-30285*#** Dayton Univ., Ohio.

**THE PHYSICAL AND EMPIRICAL BASIS FOR A SPECIFIC CLEAR-AIR TURBULENCE RISK INDEX Final Report, 2 Jul. 1982 - 30 Aug. 1985**

J. L. KELLER Washington NASA Apr. 1986 48 p
(Contract NAS8-34687)
(NASA-CR-3971; NAS 1.26:3971) Avail: NTIS HC A03/MF A01 CSCL 04B

The fundamental emphasis of this research was to develop a technique which would be a significant improvement over those currently used for flight planning to avoid clear air turbulence (CAT). The technique should, ideally, be both quantitative in determining potential intensity and specific in locating regions of relatively high risk. Furthermore, it should not rely on specialized data but be functional using the currently available rawinsonde observation (raob) system. Encouraging results documented in an earlier investigation were considered compelling enough to warrant a closer look into the possibilities of a Specific Clear Air Turbulence Risk (SCATR) index approach to the clear air turbulence problem. Unlike that research, which considered sustained periods of flight in light to moderate clear air turbulence, this study focuses on several cases of documented severe CAT. Results of these case studies suggest that a SCATR index is not an unrealizable goal and that uses of such an index, event in its current prototype level of development, are also apparent. Author

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## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A86-43476#**

**APPLICATION OF ADAPTIVE CONTROL TO AIRCRAFT SYSTEMS**

Z. CHEN and H. ZHANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 513-520. In Chinese, with abstract in English. refs

The competition of the adaptive technique with other techniques is reviewed. The inherent drawback of the adaptive technique in application to aircraft systems is considered in the light of the analysis of the features of flight control systems. The potentials and perspectives of the adaptive technique are also suggested. The development of advanced aircraft demands performance beyond the capacity of the airdata scheduling technique. Therefore, the adaptive control schemes are expected to be applied to these flight control problems. In order to make full use of the advantages, such as saving sensor hardware, requiring less prior knowledge of aircraft and providing higher flexibility, it is necessary to carry out robustness research of existing adaptive control schemes and to develop new more robust adaptive control schemes. Author

**A86-43482#**

**AN OPTIMAL PARAMETER ESTIMATION METHOD COMPATIBLE WITH STABLE PARAMETER PREDICTION IN TIME DOMAIN**

H. GAN and Y. WU (Harbin Institute of Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 565-571. In Chinese, with abstract in English. refs

A compatible identification algorithm is presented, in which the Lainiotis (1976) general partitioning identification algorithm (GPIA) is combined with the model reference identification algorithm (MRIA) based on the stability theory of Liapunov. By means of this algorithm, the residuals of the system can approach to zero asymptotically and variance of the residuals can be minimized. In the GPIA-MRIA algorithm, GPIA gives a linear optimal estimation of state and parameters according to a finite measurement set, and MIRA offers an asymptotical approach of the models. This means that GPIA contributes the state estimator of MRIA on the one hand, and on the other hand MRIA predicts the parameters and adjusts the model of GPIA to an optimal estimation of the parameters. This method has been applied to identification of aerodynamic coefficients and control derivatives of an aircraft, by means of digital simulation. It is shown that this method is superior to the single GPIA in accuracy of identification and speed of convergence, and requires almost no increase in the capacity of computation. Author

**A86-43511#**

### ON A METHOD FOR PILOT DYNAMICS IDENTIFICATION REFLECTING FEEDBACK STRUCTURES

N. GOTO (Kyushu University, Fukuoka, Japan) Kyushu University, Technology Reports (ISSN 0023-2718), vol. 58, Dec. 1985, p. 985-991. In Japanese, with abstract in English. refs

A statistical method that has been used to study pilot control behavior in multiloop situations is extended to the identification of pilot dynamics in a class of feedback systems with an inner loop. The method utilizes the autoregressive scheme and determines the unknown dynamics by reducing the system to a feedback structure suited to the scheme. Distinguishing the system structure with an inner loop from other candidate system structures is possible by examining the correlation characteristics of the innovation processes as well as the identified dynamics. To test the method, a digital simulation study is conducted, treating the longitudinal flight-path control of an aircraft as an example in which the pilot is considered to tightly close the pitch-attitude-control inner loop. The results show that the method checks the feedback structure of the concernod system and yields good estimates of the unknown dynamics as well. The method seems to be feasible enough to be applied to the analysis of real flight and simulator test data. Author

**A86-43889**

### SMART BUILT-IN-TEST (BIT)

K. A. HALLER, J. D. ZBYTNIEWSKI (Grumman Aerospace Corp., Bethpage, NY), and K. ANDERSON (Bolt Beranek and Newman, Inc., Cambridge, MA) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 140-147.

This paper summarizes the Smart BIT study performed under contract to Rome Air Development Center, Griffiss Air Force Base, NY. Current and state-of-the-art design techniques for Built-In-Test (BIT) were surveyed along with Artificial Intelligence (AI) techniques applicable to the identification and reduction of BIT false alarms and intermittents. Analysis of each potentially useful concept ascertained which techniques would be feasible for system application. Techniques were selected from those deemed feasible and several were incorporated as part of the demonstration system. An AI diagnostic program on a remote LISP machine performed the levels of reasoning required to identify false alarms inserted under the control of a local computer connected to the test unit. Author

**A86-44505**

### SINUSOIDAL DISTURBANCE REJECTION WITH APPLICATION TO HELICOPTER FLIGHT DATA ESTIMATION

G. C. GOODWIN, R. J. EVANS (Newcastle, University, Australia), R. L. LEAL (Centro de Investigaciones y Estudios Avanzados, Mexico City), and R. A. FEIK (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IEEE Transactions on Acoustics, Speech, and Signal Processing (ISSN 0096-3518), vol. ASSP-34, June 1986, p. 479-484. refs

This paper is concerned with the problem of eliminating sinusoidal disturbances from data while producing minimal distortion to the underlying data. A particular example of this problem arises in the filtering of helicopter data which are corrupted by sinusoidal disturbances due to rotor motion. It is shown that an optimal solution to the problem can be found using Kalman filtering theory. The properties of the optimal filter are analyzed using recent results on filtering for nonstabilizable systems. These results are then used to motivate a particular near-optimal filter which has enhanced robustness properties relative to the optimal filter. It will be shown that an identical filter can be derived using recent results on the evaluation of recursive discrete Fourier transforms. This link between time and frequency domain methods leads to a rather complete understanding of the characteristics of the filter. Specific results are presented showing the application of the filter to real helicopter data. Author

**A86-45473**

### RECTANGULAR PARALLELEPIPED CODING - A VOLUMETRIC REPRESENTATION OF THREE-DIMENSIONAL OBJECTS

Y. C. KIM and J. K. AGGARWAL (Texas, University, Austin) IEEE Journal of Robotics and Automation (ISSN 0882-4967), vol. RA-2, Sept. 1986, p. 127-134. refs
(Contract F49620-85-K-0007)

A new three-dimensional object representation scheme called rectangular parallelepiped coding is presented. Rectangular parallelepiped coding is an extension to three-dimensional space of the two-dimensional rectangular coding scheme. It is a volume-based representation of three-dimensional objects constructed from three orthogonal views (silhouettes) of the object using volume intersection method and is coded as a list of rectangular parallelepipeds. The representation is versatile and easily edited. For the objects coded in this representation, the operations of translation, rotation, and scaling are easily performed and the properties of volume, surface, and moments are easily computed. Examples are given for which processing time and storage requirements are examined. Author

**A86-45725**

### USE OF BLOCK-PULSE FUNCTIONS IN THE OPTIMAL CONTROL OF DETERMINISTIC SYSTEMS

C. HWANG, D.-H. SHIH, and F.-C. KUNG (National Cheng Kung University, Tainan, Republic of China) International Journal of Control (ISSN 0020-7179), vol. 44, Aug. 1986, p. 343-349. refs

The synthesis of an optimal control function for deterministic systems described by intergrodifferential equations is investigated. By using the elegant operational properties of block-pulse functions, a directly computable algorithm for evaluating the optimal control and trajectory of deterministic systems is developed. An example is given to illustrate the utility of this method. Author

**A86-45736**

### THE SINGULAR-G METHOD FOR UNSTABLE NON-MINIMUM-PHASE PLANTS

I. HOROWITZ (California, University, Davis; Weizmann Institute of Science, Rehovot, Israel) International Journal of Control (ISSN 0020-7179), vol. 44, Aug. 1986, p. 533-541. refs
(Contract NSF ECS-83-03333; F33615-83-C-3000)

In linear time-invariant feedback systems with plants which have both poles and zeros in the right half-plane, it is always possible to stabilize the system for a fixed plant. But in the previous optimum techniques, the stability margins might be so small as to render the design wholly impractical. This problem was overcome in the X-29 aircraft in a multiple-input-multiple-output (MIMO) setting, by use of a singular-G (compensation) matrix inside the loop. Excellent stability margins were then achievable over a wide plant parameter range, by means of a fixed-G compensation matrix. This paper extends the singular-G technique to the single-input-single-output plant. The latter is converted into an equivalent N x N MIMO plant by means of N parallel independent time-varying modulators acting on the plant output, a technique previously used for nonlinear network synthesis. The singular-G method is then applicable to the equivalent N x N MIMO plant. The detailed design procedure is presented by means of an example with $N = 2$. Author

**A86-46369#**

**SIMULATION OF THE ALGORITHMS OF A NAVIGATION COMPUTER [SYMULACJA ALGORYTMOW KOMPUTERA NAWIGACYJNEGO]**

M. LIJOWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 103, 1985, p. 37-52. In Polish. refs

Methods for determining the position of an aircraft on the basis of the signals obtained from the air data unit, an induction gyrocompass, two VOR receivers, an automatic direction finder and a Doppler radar set are discussed. Problems connected with the search for radio stations of optimum location are explained as algorithms for the joint operation of the navigation computer with the map indicator. The programs were tested, showing the correctness of the proposed algorithms and the possibility of their realization in real time. Author

**A86-46377**

**A FAST SHAPE DESCRIPTOR**

J. MA, C.-K. WU, and X.-R. LU (Northwest Telecommunication Engineering Institute, Xian, People's Republic of China) Computer Vision, Graphics, and Image Processing (ISSN 0734-189X), vol. 34, June 1986, p. 282-291. refs

A fast normalized shape descriptor for digital pattern-recognition and classification applications is developed and demonstrated. The descriptor employs the rapid transformation of Reitboeck and Brody (1968), preceded by a distance transform to assure invariance to rotation. The performance of the descriptor is compared experimentally with that of a normalized Fourier descriptor (Wallace and Wintz, 1980) in problems involving two-dimensional aircraft images. The new descriptor is found to be faster than and just as accurate as the Fourier descriptor, and to require significantly less memory storage capacity. T.K.

**A86-46401**

**CONTROLLABILITY THEORY OF DISCRETE DYNAMIC SYSTEMS**

R. G. FARADZHEV, MR. PHAT VU NGOC, and A. V. SHAPIRO Automation and Remote Control (ISSN 0005-1179), vol. 47, no. 1, June 10, 1986, pt. 1, p. 1-20. Translation. refs

The current status of discrete dynamics systems controllability theory is reviewed as well as applications and prospects for further development. Consideration is given to systems that are linear, bilinear, nonlinear, finite, ordinary modified and multiparameter in nature. It is noted that the theory of controllability in time systems is applied in such areas as biology, mechanics, and aircraft/spacecraft control; in multiparameter systems, this theory plays a major role in designing the means for digital display processing and multidimensional data arrays. In the case where space-time multidimensional discrete systems are combined with finite control methods, the theory of controllability potentially plays a significant role in synthesizing optimal high-speed antenna arrays and plasma processes. Problems related to these applications are discussed. K.K.

**A86-46706**

**APPLICATIONS OF ARTIFICIAL INTELLIGENCE II; PROCEEDINGS OF THE MEETING, ARLINGTON, VA, APRIL 9-11, 1985**

J. F. GILMORE, ED. (Georgia Institute of Technology, Atlanta) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 548), 1985, 275 p. For individual items see A86-46707 to A86-46717.

(SPIE-548)

The present conference considers topics in image segmentation and texture analysis, robotic vision, image understanding, expert system design, motion planing, and heuristic systems. Attention is given to the use of texture operators in segmentation, knowledge-based terrain analysis, a computer vision system for the identification of overlapping workpieces, stereopsis and scene partitioning for terrain interpretation, and the shape recognition of complex objects by syntactical primitives. Also discussed are the application of expert system techniques to a visual tracker, knowledge-based route planning through natural terrain, decision-aiding for tactical aircraft, a model-based system for force structure analysis, search processes for artificial intelligence applications, a hierarchical planner for intelligent systems, an analysis of motion patterns generated by moving shapes, the role of understanding in automated program synthesis, and the detection of objects in high resolution multispectral aerial images. O.C.

**A86-46791**

**REMARKS ON THE DEVELOPMENT OF A MULTIBLOCK THREE-DIMENSIONAL EULER CODE FOR OUT OF CORE AND MULTIPROCESSOR CALCULATIONS**

A. JAMESON (Princeton University, NJ), S. LEICHER (Dornier GmbH, Friedrichshafen, West Germany), and J. DAWSON (Cray Research, Inc., Minneapolis, MN) IN: Progress and supercomputing in computational fluid dynamics; Proceedings of U.S.-Israel Workshop, Jerusalem, Israel, December 1984 . Boston, MA, Birkhaeuser, 1985, p. 53-66 refs

A multiblock modification of the FLO57 code for three-dimensional wing calculations is described and demonstrated. The theoretical basis of the multistage time-stepping algorithm is reviewed; the multiblock grid structure is explained; and results from a computation of vortical flow past a delta wing, using 2.5 x 10 to the 6th grid points and performed on a Cray X/MP computer with a 128-Mword solid-state storage device, are presented graphically. T.K.

**N86-30349*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DEVELOPMENT OF AN ALGORITHM TO MODEL AN AIRCRAFT EQUIPPED WITH A GENERIC CDTI DISPLAY**

W. C. DRISCOLL (Youngstown State Univ., Ohio.) and J. A. HOUCK Jul. 1986 58 p

(NASA-TM-87732; NAS 1.15:87732) Avail: NTIS HC A04/MF A01 CSCL 12A

A model of human pilot performance of a tracking task using a generic Cockpit Display of Traffic Information (CDTI) display is developed from experimental data. The tracking task is to use CDTI in tracking a leading aircraft at a nominal separation of three nautical miles over a prescribed trajectory in space. The analysis of the data resulting from a factorial design of experiments reveals that the tracking task performance depends on the pilot and his experience at performing the task. Performance was not strongly affected by the type of control system used (velocity vector control wheel steering versus 3D automatic flight path guidance and control). The model that is developed and verified results in state trajectories whose difference from the experimental state trajectories is small compared to the variation due to the pilot and experience factors. Author

**N86-30371*#** Texas Technological Coll., Lubbock. Dept. of Electrical Engineering/Computer Science.

**A CANONICAL FORM FOR NONLINEAR SYSTEMS**

R. SU and L. R. HUNT (Texas Univ., Dallas.) 1986 21 p

(Contract NAG2-203; NAG2-189; N0014-76-C-1136; N00014-84-C-0104)

(NASA-CR-176974; NAS 1.26:176974) Avail: NTIS HC A02/MF A01 CSCL 09B

The concepts of transformation and canonical form have been used in analyzing linear systems. These ideas are extended to nonlinear systems. A coordinate system and a corresponding canonical form are developed for general nonlinear control systems. Their usefulness is demonstrated by showing that every feedback linearizable system becomes a system with only feedback paths in the canonical form. For control design involving a nonlinear system, one approach is to put the system in its canonical form and approximate by that part having only feedback paths.

Author

**N86-30648#** London Univ. (England). Dept. of Aeronautical Engineering.

**FINITE STATE MODELLING OF AEROELASTIC SYSTEMS FOR ACTIVE CONTROL APPLICATIONS: A GENERAL THEORY**

R. VEPA *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 309-319 1985
Avail: NTIS HC A99/MF E03

The theory of modeling aeroelastic systems by finite state models is discussed. The models are classified as autonomous finite state models, time varying system models, and differential delay system models. It is shown that control law synthesis for active control can be performed using the differential delay model, which does not contribute to any additional states and is valid for the closed and open loop cases. However, control law implementation requires that the states used for feedback be measured directly or estimated from measurements which are linear combinations of system states. Direct measurements of all feedback states is probably not practical so that sensor output data processing is required. Two alternatives are the statistical Kalman-Bucy filter with error dynamics governed by the statistics of the measurements noise, and a state estimator with error dynamics selected arbitrarily. ESA

**N86-31237*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**GEOMETERIAL DESCRIPTION FOR A PROPOSED AEROASSIST FLIGHT EXPERIMENT VEHICLE**

F. M. CHEATWOOD, F. J. DEJARNETTE (North Carolina State Univ., Raleigh.), and H. H. HAMILTON, II Jul. 1986 38 p
(NASA-TM-87714; NAS 1.15:87714) Avail: NTIS HC A03/MF A01 CSCL 09B

One geometry currently under consideration for the Aeroassist Flight Experiment (AFE) vehicle is composed of several segments of simple general conics: an ellipsoidal nose tangent to an elliptical cone and a base skirt with the base plane raked relative to the body axis. An analytic representation for the body coordinates and first and second partial derivatives of this configuration has been developed. Equations are given which define the body radius and partial derivatives for a prescribed axial and circumferential position on the vehicle. The results for a sample case are tabulated and presented graphically. Author

**N86-31265*#** Toledo Univ., Ohio. Dept. of Electrical Engineering.

**CONTROL DESIGN FOR ROBUST STABILITY IN LINEAR REGULATORS: APPLICATION TO AEROSPACE FLIGHT CONTROL Final Report, 1 Jun 1985 - 17 Jul. 1986**

R. K. YEDAVALLI 1986 63 p
(Contract NAG1-578)
(NASA-CR-176858; NAS 1.26:176858) Avail: NTIS HC A04/MF A01 CSCL 09B

Time domain stability robustness analysis and design for linear multivariable uncertain systems with bounded uncertainties is the central theme of the research. After reviewing the recently developed upper bounds on the linear elemental (structured), time varying perturbation of an asymptotically stable linear time invariant regulator, it is shown that it is possible to further improve these bounds by employing state transformations. Then introducing a quantitative measure called the stability robustness index, a state feedback conrol design algorithm is presented for a general linear regulator problem and then specialized to the case of modal systems as well as matched systems. The extension of the algorithm to stochastic systems with Kalman filter as the state estimator is presented. Finally an algorithm for robust dynamic compensator design is presented using Parameter Optimization (PO) procedure. Applications in a aircraft control and flexible structure control are presented along with a comparison with other existing methods. Author

**N86-31420*#** Prairie View Agricultural and Mechanical Coll., Tex. Dept. of Mechanical Engineering.

**DEVELOPMENT OF A NUMERICAL PROCEDURE TO MAP A GENERAL 3-D BODY ONTO A NEAR-CIRCLE**

M. J. HOMMEL *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 5 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 12A

Conformal mapping is a classical technique utilized for solving problems in aerodynamics and hydrodynamics. Conformal mapping is utilized in the construction of grids around airfoils, engine inlets and other aircraft configurations. These shapes are transformed onto a near-circle image for which the equations of fluid motion are discretized on the mapped plane and solved numerically by utilizing the appropriate techniques. In comparison to other grid-generation techniques such as algerbraic or differential type, conformal mapping offers an analytical and accurate form even if the grid deformation is large. One of the most appealing features is that the grid can be constrained to remain orthogonal to the body after the transformation. Hence, the grid is suitable for analyzing the supersonic flow past a blunt object. The associated shock as a coordinate surface adjusts its position in the course of computation until convergence is reached. The present work applied conformal mapping to 3-D bodies with no axis of symmetry such as the Aerobraking Flight Experiment (AFE) vehicle, transforming the AFE shape onto a near-circle image. A numerical procedure and code are used to generate grids around the AFE body. Author

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## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A86-44805**

**MODELLING OF ACOUSTIC RADIATION PROBLEMS ASSOCIATED WITH TURBOMACHINERY AND ROTATING BLADES**

W. EVERSMAN (Missouri-Rolla, University, Rolla) IN: Flow of real fluids . Berlin and New York, Springer-Verlag, 1985, p. 63-72. refs

Finite element methods developed for computational predictions of turbofan and propeller acoustic radiation are presented. Account is taken of the disparate acoustic and geometric scales, the complex geometry, sound propagation in a nonuniformly flowing medium, the presence of a lining, and definition of bounds for calculations which are carried out in an unbounded domain. Density and pressure perturbations in the turbofan inlet are modeled with a linearized momentum equation. The sound radiation is represented by the Fourier components, i.e., angular modes. The same nacelle geometry is used for propeller noise, which requires inclusion of acoustic volume sources and forces. A forced convected wave equation for harmonic driving is obtained by combining continuity, momentum and state equations linearized for acoustic perturbations. The weak formulations for the two types of noise generation are solved by the Galerkin method modified with a frontal solver to reduce the required computer time. Model predictions show good agreement with experimental data for the directivity and amplitude of sound from the bellmouth inlet of the NASA-Langley Spinning Mode Synthesizer. M.S.K.

**A86-45401*#** Cornell Univ., Ithaca, N.Y.
**HELICOPTER TAIL ROTOR NOISE**
S.-T. CHOU and A. R. GEORGE (Cornell University, Ithaca, NY) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p. NASA-supported research. Previously announced in STAR as N86-26163. refs
(AIAA PAPER 86-1900)

A study was made of helicopter tail rotor noise, particularly that due to interactions with the main rotor tip vortices, and with the fuselage separation mean wake. The tail rotor blade-main rotor tip vortex interaction is modelled as an airfoil of infinite span cutting through a moving vortex. The vortex and the geometry information required by the analyses are obtained through a free wake geometry analysis of the main rotor. The acoustic pressure-time histories for the tail rotor blade-vortex interactions are then calculated. These acoustic results are compared to tail rotor loading and thickness noise, and are found to be significant to the overall tail rotor noise generation. Under most helicopter operating conditions, large acoustic pressure fluctuations can be generated due to a series of skewed main rotor tip vortices passing through the tail rotor disk. The noise generation depends strongly upon the helicopter operating conditions and the location of the tail rotor relative to the main rotor. Author

**A86-45402#**
**CALCULATION OF TRANSONIC ROTOR NOISE USING A FREQUENCY DOMAIN FORMULATION**
J. PRIEUR (ONERA, Chatillon-sous-Bagneux, France) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. Research supported by the Ministere de la Defense. refs
(AIAA PAPER 86-1901)

This paper presents a formulation of the prediction of transonic quadrupolar rotor noise in hover by means of a frequency domain method. An application is made to a model rotor. Tests on the computational stability of the method are presented and theoretical results are compared with published experimental data. Noise predictions on rotors with swept-tip blades are made and discussed. Author

**A86-45403#**
**HIGH SPEED ROTOR NOISE DUE TO BLADE LOADING**
R. DASH (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs
(AIAA PAPER 86-1902)

An equation for the far field radiated sound due to dipole sources, which results from blade loading, is derived using the theories of Lowson (1965) and Ffowcs et. al. (1969). The power spectral density (PSD) of the pressure field in a far field is analyzed. The effects caused by the Doppler shift in the amplitude and in the PSD of load fluctuations are considered. The equation relates the PSD of a time-dependent dipole strength to the PSD of the pressure fluctuation in the distant radiation field. The theory is employed to study fan noise, and a modified form of the Gutin theory of propeller noise is developed. The application of the data to the prediction of helicopter rotor noise and broadband noise is discussed. I.F.

**A86-45404*#** United Technologies Research Center, East Hartford, Conn.
**ROTOR NOISE DUE TO ATMOSPHERIC TURBULENCE INGESTION. II AEROACOUSTIC RESULTS**
R. K. AMIET, J. C. SIMONICH, and R. H. SCHLINKER (United Technologies Research Center, East Hartford, CT) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs
(Contract NAS1-17096)
(AIAA PAPER 86-1903)

A computer program for the prediction of noise due to the turbulence of inflow to a propeller or helicopter rotor is extended to the case of nonisotropic turbulence, on the basis of a combined mean flow contraction model and rapid distortion theory. The mean flow distortion is noted to stretch the turbulence, decreasing the velocities along the principal axis of the stretching. In the case of a principal stretching axis lying close to the rotor axis, the distortion acts to decrease the upwash velocities of the rotor; thereby decreasing the noise from levels associated with isotropic turbulence. Acoustic energies are calculated at observer location for several cases, and compared to the turbulence energy as affected by the contraction. O.C.

**A86-45405*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**APPLICATION OF THE BASELINE ROTONET SYSTEM TO THE PREDICTION OF HELICOPTER TONE NOISE**
R. A. GOLUB (NASA, Langley Research Center, Hampton, VA), D. S. WEIR, and M. B. TRACY (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. refs
(AIAA PAPER 86-1904)

The capabilities of the baseline Rotonet system designed to predict helicopter noise are analyzed. The modules of the system utilized for main and tail rotor geometry and blade section aerodynamic characteristics, for analyses, and for source-to-observer geometry, and atmospheric and ground effects calculations are described; a diagram of the system is provided. The Rotonet system produces axial force, tone noise, and sound pressure level information and a one third octave spectrum related to rotor tone noise and broadband noise sources. Main rotor noise predictions are compared with flight data. It is observed that both sets of data reveal increase loading on the advancing side and decrease loading on the retreating side. The tone noise and sound pressure levels for the first and second harmonics correlate well with the flight data; however, there is only fair agreement for the third harmonics of the sound pressure level. Analysis of the spectra display lower noise levels for higher altitudes and lower speeds. It is noted that the baseline Rotonet system is applicable for predicting performance and noise signatures for the lower harmonics. A phase II Rotonet system for evaluating higher harmonics is being developed. I.F.

**A86-45408#**
**SOUND TRANSMISSION THROUGH DOUBLE PANEL CONSTRUCTIONS LINED WITH ELASTIC POROUS MATERIALS**
J. S. BOLTON and E. R. GREEN (Purdue University, West Lafayette, IN) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs
(AIAA PAPER 86-1907)

Attention is given to a theory governing one-dimensional wave motion in elastic porous materials which is capable of reproducing experimental transmission measurements for unfaced polyurethane foam layers. Calculations of the transmission loss of fuselage-like foam-lined double panels are presented and it is shown that the foam/panel boundary conditions have a large effect on the panel performance; a hybrid arrangement whereby the foam is bonded directly to one panel and separated from the other by a thin air gap appears to be the most advantageous under practical circumstances. With this configuratiom, the mass-air-mass resonance is minimized and increased low-frequency performance is offered. K.K.

**A86-45417#**
**THE EFFECT ON RADIATED NOISE OF NON-ZERO PROPELLER ROTATIONAL PLANE ATTITUDE**
W. M. DOBRZYNSKI (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 15 p. Research supported by the Bundesministerium fuer Verkehr, FAA and BMFT. refs
(AIAA PAPER 86-1926)

Subsequent to CAEP's decision to introduce a new noise certification procedure, a joint attempt was made by the FAA and DFVLR to quantitatively determine the influence of a nonzero propeller-disk attitude on the resulting noise; tests were conducted with the German Dutch Wind Tunnel (DNW) in its aeroacoustic mode. It was found that the effect of propeller disk-plane attitude on maximum overall A-weighted noise levels can be related to a steady-state Mach number effect for the propeller operating at subsonic helical blade-tip (HBT) Mach-numbers exceeding a value of 0.7. For HBT Mach-numbers significantly below 0.7, additional noise radiation due to the unsteady flow properties within one propeller revolution dominate the overall A-weighted noise levels. K.K.

**A86-45418*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### COUNTER-ROTATING PROPELLER NOISE DIRECTIVITY AND TRENDS

P. J. W. BLOCK (NASA, Langley Research Center, Hampton, VA), R. J. KLATTE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), and P. M. DRUEZ (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs
(AIAA PAPER 86-1927)

The effects of power loading on the far field noise spectra and directivity of counter-rotating propellers (CRP) were studied using a model scale SR-2 propeller in a low-speed anechoic wind tunnel. Approximately 264 far field noise measurements were obtained for each CRP configuration (pusher and tractor) and operating conditions covering from 30 to 140 deg to the flight direction and up to 340 deg circumferentially. Data indicated that the CRP tractor produced higher levels in the second and third harmonics which propagated axially; in effect, the noise exposure time increased over that of a single single-rotation propeller. The effects of pylon-to-propeller spacing, type of pylon attachment and reduced rear-blade row radius are considered and it is found that the 0.3 chord radial pylon produces less additional noise than the 0.1 chord radial pylon and that the 0.2 chord tangential pylon is the quietest pusher configuration. K.K.

**A86-45419#**

### EXPERIMENTAL RESULTS OF THE NOISE RADIATION OF PROPELLERS IN NON-UNIFORM FLOWS

I. U. BORCHERS, R. SCHOLTEN (Dornier GmbH, Friedrichshafen, West Germany), and B. W. GEHLHAR (DFVLR, Brunswick, West Germany) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs
(Contract BMFT-LKV-8330)
(AIAA PAPER 86-1928)

The noise radiation of propellers operating in airfoil or fuselage wakes is studied via 1:7 model-scale wind-tunnel testing. The effect of the wake is assessed for a variety of propeller parameters and flow data and the influence of reflecting surfaces in the propeller near-field (given by aircraft T-type tail units) is investigated. The wake results in an increase in noise generation occurring primarily at the higher harmonics and in the upstream direction. Tests with the reflecting surfaces reveal that T-type horizontal tails may effect both the far-field noise levels for rear-mounted propellers and the upstream near-field noise close to the rear fuselage section. K.K.

**A86-45420*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### PUSHER PROPELLER NOISE DIRECTIVITY AND TRENDS

P. J. W. BLOCK (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs
(AIAA PAPER 86-1929)

The effects of pylon wake interaction on far-field propeller noise are studied using a model scale SR-2 propeller in a low-speed anechoic wind tunnel. The variation in the pusher noise penalty with axial angle theta and circumferential angle phi is compared to that of the tractor noise penalty; and the former exhibits minima occurring in the propeller plane and maxima occurring toward the propeller axis. The magnitude of the pusher installation noise penalty decreased with in increase in shaft horsepower and tip Mach number. Directivity comparisons revealed that both a noise reduction and a directivity pattern change resulted when the pylon was moved farther from the propeller. Noise emerging from the wake interaction was distinguished from that of the propeller by means of a modal decomposition. K.K.

**A86-45421*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### PREDICTED AND MEASURED STRAIN RESPONSE OF RECTANGULAR PANELS DUE TO ACOUSTIC LOADING

L. A. ROUSSOS, K. E. HEITMAN, and C. E. RUCKER (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs
(AIAA PAPER 86-1931)

The objective of the research described in this paper is to assess the accuracy of classical linear acceleration/strain prediction theory for flat, rectangular panels excited by low level, acoustic plane waves. Predictions for both aluminum and laminated composite panels were based on the Ritz method using an orthotropic, multi-mode analysis with rotational springs on the boundaries. The measured natural frequencies and critical damping ratio of the panels were empirial inputs to the model. The comparison between measured and predicted acceleration was very good. Although a factor of three bias error was found between measured and predicted strains, the model was good for predicting the trends in the spatial variation in strain across the panel. Author

**A86-45430*#** Florida State Univ., Tallahassee.

### THE NEAR AND FAR ACOUSTIC FIELDS OF BROADBAND SHOCK ASSOCIATED NOISE

C. K. W. TAM (Florida State University, Tallahassee) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 15 p. refs
(Contract NAG1-421)
(AIAA PAPER 86-1943)

A stochastic model theory is presented which suggests that the broadband shock associated noise of supersonic jets is generated by the weak interaction between downstream propagating large turbulence structures and the quasiperiodic shock cells in the jet plume The large turbulence structures are modelled by a superposition of the intrinsic instability waves of the mean flow of the jet, and the quasiperiodic shock cells are broken down into time-independent waveguide modes of the jet flow using multiple scales expansion. The observed broadband shock associated noise consists of a superposition of the spectra generated by the different waveguide modes. Starting from the equations of motion of a compressible fluid, formulas for calculating the far field and near field noise are developed. Good general agreement is found with previous results. R.R.

**A86-45431#**

### HIGH SPEED FLIGHT EFFECTS ON SHOCK ASSOCIATED NOISE

W. H. BROWN, K. K. AHUJA, and C. K. W. TAM (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. Research sponsored by the Lockheed-Georgia Co.
(AIAA PAPER 86-1944)

An experimental study was conducted to evaluate the effects of high speed flight on shock associated noise. This study was conducted in the Lockheed anechoic wind tunnel using flow from a 4-inch diameter pipe for flight simulation and a 0.4-inch diameter flow to simulate the supersonic jet. Acoustic measurements were made in the farfield and within the flight simulation flow for simulated flight Mach numbers up to 0.8 for unheated jet Mach numbers of 1.42 and 1.49. It is shown that the peak frequency of the shock-associated noise decreases with increasing flight speed. Similarly, shock-associated broadband noise magnitude was observed to increase with flight velocity. Author

**A86-45432*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SHOCK NOISE FROM SUPERSONIC JETS IN SIMULATED FLIGHT TO MACH 0.4**

T. D. NORUM and J. G. SHEARIN (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs

(AIAA PAPER 86-1945)

Simulated flight experiments to Mach 0.4 on underexpanded jets show that flight has only minor effects on both the shock structure and shock associated noise. Although screech modes that do not exist statically become dominant at the higher flight speeds, the screech amplitudes and directivity as well as the broadband shock noise amplitudes remain relatively constant as the forward speed is increased. The change in wavelength due to flight on both shock noise components are predicted well from existing theories of shock noise. Author

**A86-45433*#** Syracuse Univ., N. Y.

**AEROACOUSTICS OF CONTOURED PLUG-NOZZLE SUPERSONIC JET FLOWS**

D. S. DOSANJH (Syracuse University, NY) and I. S. DAS (Pennsylvania State University, Sharon) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 17 p. refs

(Contract NAG1-129)

(AIAA PAPER 86-1946)

Experimental investigations of the acoustic far-field, the shock associated noise, and the characteristics of the repetitive shock structure of supersonic jet flows issuing from a plug-nozzle having an externally expanded contoured plug with a pointed termination, operated at a range of supercritical pressure ratios of 2.0 to 4.5 are reported. The supersonic jet flow from the contoured plug is shown to be shock-free and virtually wakeless at a pressure ratio of 3.60 (flow Mach number, 1.49). By comparison with the noise characteristics of underexpanded jet flows from an equivalent convergent nozzle, substantial reductions in the total (mixing and the shock associated) noise levels are obtained when the contoured plug nozzle is operated either in the fully-expanded (shock-free) mode or in the over- and the underexpanded modes. Author

**A86-45434#**

**TONE-LIKE NOISE FROM AN ISOLATED TWO DIMENSIONAL AIRFOIL**

S. AKISHITA (Mitsubishi Electric Corp., Amagasaki, Japan) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs

(AIAA PAPER 86-1947)

The frequencies of a tone-like noise consisting of a series of tones radiating from isolated two-dimensional NACA 0015 airfoils are investigated, in addition to the effect of a trip wire in the boundary layer. It is found that the index in the power law of the tone-like noise is far less than that of the broadband noise, and that the tone frequencies increase with flow velocity and decrease with chord length. The results show that the tone-like noise relates to linear instability of the boundary layer on the pressure surface. Based on flow turbulence measurements in the boundary layer, and flow visualization by an oil film technique, a new model is proposed of a self-excited feedback loop consisting of the turbulent boundary layer downstream of a laminar separation bubble, and the wake flow near the trailing edge. R.R.

**A86-45435#**

**BROAD BAND NOISE FROM AN ISOLATED TWO DIMENSIONAL AIRFOIL**

S. AKISHITA and K. OHTSUTA (Mitsubishi Electric Corp., Amagasaki, Japan) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs

(AIAA PAPER 86-1948)

The turbulence noise characteristics from an isolated two-dimensional airfoil immersed in low turbulence uniform flow are investigated for axial-flow fans at Reynolds numbers applicable to full scale rotors. The far-field noise is characterized as broadband noise (BBN) and tone-like high-frequency noise. The BBN is found to predominate over the tone-like noise in flow and wing geometry conditions of low camber, small thickness ratio, and low incidence flow angle. The BBN overal intensity is proportional to the 5th or 6th power of the flow velocity, and is related to the characteristics of the boundary layer near the trailing edge. The BBN spectrum level and peak frequency are found to depend on the wing geometry parameters and the flow characteristics. The BBN directivity resembles a point dipole, and the surface dipole strength distribution of the BBN along the chordwise direction is shown to increase from the leading edge towards the trailing edge. R.R.

**A86-45443#**

**ACTIVE MINIMISATION OF ACOUSTIC POTENTIAL ENERGY IN HARMONICALLY EXCITED CYLINDRICAL ENCLOSED SOUND FIELDS**

A. J. BULLMORE, P. A. NELSON, and S. J. ELLIOTT (Southampton, University, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs

(AIAA PAPER 86-1958)

Quadratic optimization theory is used to apply active noise control methods to the control of cylindrical enclosed sound fields which are harmonically excited due to the structural response of a surrounding thin cylindrical shell excited by two harmonic point forces. Using ten secondary control sources, it is shown that reductions of up to 5.7 dB in the total time averaged acoustic potential energy in the enclosure can be realized in a cylinder with dimensions typical of a 50-seat propeller driven aircraft, and being driven at a frequency typical of propfan blade passage frequency. It is noted, however, that the model may not give reliable predictions of reductions possible in real aircraft due to the highly selective nature of the coupling between structural and acoustic modes in the model used. R.R.

**A86-45444*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ADVANCED TURBOPROP AIRCRAFT NOISE ANNOYANCE - A REVIEW OF RECENT NASA RESEARCH**

D. A. MCCURDY, J. D. LEATHERWOOD (NASA, Langley Research Center, Hampton, VA), and K. P. SHEPHERD (Bionetics Corp., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 14 p. refs

(AIAA PAPER 86-1959)

Passenger and community response to advanced turboprop aircraft noise are studied. Four experiments were conducted utilizing an aircraft noise synthesis system, an exterior effects room, an anechoic listening room, and a Space Station/aircraft acoustic apparatus; the experimental conditions and procedures for the psychoacoustic studies are described. The community noise studies involved evaluating the effects of various tonal characteristics on annoyance. It was observed that the frequency envelope shape did not effect annoyance; however, the interaction of the fundamental frequency with tone-to-broadband noise ratio did have a large effect on annoyance. The effects of low frequency tones, turbulent boundary layer noise, and tonal beats on passenger annoyance are investigated. The data reveal that passenger annoyance is greater for a given level of boundary layer noise when tones are at levels sufficient to increase the overall sound pressure level within the cabin. The annoyance response of an advanced turboprop and a conventional aircraft are compared. It is determined that the flyover noise level for the turboprop aircraft is not more annoying than that of a conventional aircraft. I.F.

**A86-45445#**

**AIRCRAFT NOISE MEASUREMENT - ALTERNATIVES TO THE STANDARD 1-2 METRES MICROPHONE HEIGHT**

M. J. T. SMITH (Rolls-Royce, Ltd., Derby, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs

(AIAA PAPER 86-1960)

The results of tests carried out on alternative microphone configurations are presented and related to previous work. Consideration is given to (1) a 'reference' microphone flush in the hard test bed surface, (2) the international standard 1.2-m height grazing incident system over grass, (3) an inverted microphone with its diaphragm 15 mm above and at 3/4 radius on a 40-cm diameter heavy metal plate, and (4) a 10-m height grazing incidence microphone over grass. It is concluded that the alternative ground-based microphone presently being considered by ICAO for propeller-powered light aircraft noise certification is technically advantageous. It is recommended that comparative measurements be made between the 1.2 m standard and alternative ground-based systems to provide data as close to pressure-doubled as possible and to define the corrections that will be necessary for adjustment of ground-based data to average 1.2-m levels. K.K.

**A86-45447#**

**BROADBAND NOISE - ITS PREDICTION AND LIKELY IMPORTANCE FOR ADVANCED PROPFANS**

K. KNOWLES (Royal Military College of Science, Shrivenham, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs

(AIAA PAPER 86-1963)

A comparison of published experimental results and analytical results on broadband noise evaluations for rotating many-bladed propellers has been conducted to assess the importance of broadband noise in the perceived noise (PN) level of propfans. It is concluded that, in cruise conditions, the tone noise dominates the broadband noise of typical propfans by 8 dB. As the speed is reduced, and the values of forward Mach number and helical tip Mach number are reduced, the tones fall more rapidly than the broadband component until, at approach conditions, the broadband noise is dominant by 8 to 16 PNdB. A survey of the state-of-the-art of broadband noise prediction suggests that the broadband noise can be predicted to within 5 dB. I.S.

**A86-45448#**

**BROADBAND PROPELLER NOISE PREDICTION IN THE PLANE OF THE ROTOR**

S. A. L. GLEGG (Florida Atlantic University, Boca Raton, FL) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. refs

(AIAA PAPER 86-1964)

The unsteady thickness noise of Hawkins (1978) is shown to account for the discrepancy between the predicted broadband rotor noise, thought to consist of trailing edge and unsteady lift noise, and the observed plane rotor noise. A generalized formulation for the sound radiation of blades of finite span in linear motion is presented, and comparison of the theoretical results with noise measurements from a model scale rotor operating in a high level of turbulence demonstrates the importance of the present phenomenon. The power spectral density of the radiated acoustic pressure is also formulated in terms of the wavenumber spectrum of the inflow turbulence and blade response functions. R.R.

**A86-45451#**

**AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE PROPAGATION OF SOUND WAVES THROUGH A TURBULENT BOUNDARY LAYER**

M. SALIKUDDIN, C. K. W. TAM, R. H. BURRIN, and J. A. GALLAGHER (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 17 p. Research supported by Lockheed Independent Research and Development Program. refs

(AIAA PAPER 86-1968)

An experiment was carried out to determine the attenuation of sound crossing a turbulent boundary layer over a flat plane attached on one side of a high-speed square jet at Mach numbers approaching 0.8. Substantial transmission losses were measured and were found to increase with Mach number, frequency, and forward direction. To estimate the acoustic transmission loss as turbopropeller sound waves are transmitted through a turbulent boundary layer (TBL) on the surface of the fuselage, a theoretical model was developed in which the effect of refraction due to TBL velocity and density gradients are taken into account. It is shown that the effect of viscosity on the acoustic transmission loss depends strongly on the frequency of the sound wave and on the location relative to the propfan. Good agreement was found between the theoretical model and experimental results. K.K.

**A86-45476#**

**MID-FIELD AND FAR-FIELD CALCULATIONS OF BLADE-VORTEX INTERACTIONS**

A. R. GEORGE and A. S. LYRINTZIS (Cornell University, Ithaca, NY) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p. Research supported by the McDonnell Douglas Helicopter Co. refs

(AIAA PAPER 86-1854)

A study is made of mid-field and far-field noise generated by transonic Blade-Vortex Interactions (BVI) typical of helicopter main rotor noise. The VTRAN2 small disturbance, two-dimensional, transonic flow code which includes convected vorticity was used to compute near and mid-field flow field information. Because of mesh size limitations this information is restricted to the mid-field and does not give the desired far field and three-dimensional information. A method of extending the solutions to the far field in three dimensions is developed based on Kirchhoff's solution to the linear flow outside a surface S inclosing the nonlinear near field. A number of the directionality aspects of BVI noise are explained in terms of the propagation characteristics of the waves. The relation of unsteady 'Type C' shock motion on the airfoil to far field sound is shown. The farfield radiation was affected only weakly by Mach number in the transonic range but airfoil thickness, shape, and miss distance were found to be important. Author

**A86-45477*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CONCEPTS FOR REDUCTION OF BLADE-VORTEX INTERACTION NOISE**

J. C. HARDIN (NASA, Langley Research Center, Hampton, VA) and S. L. LAMKIN (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 7 p. refs

(AIAA PAPER 86-1855)

A model is developed to determine the critical parameters that control noise generation by blade-vortex interaction (BVI). The equations for evaluation BVI are derived. The analysis of BVI using the model reveals that the interaction is dependent on incoming vortex strength, blade lift, the interaction length, and the miss distance of the interaction. Several methods for reduction of the noise source are proposed. I.F.

**A86-45478*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SURFACE PRESSURE MEASUREMENT DURING LOW SPEED TWO-DIMENSIONAL BLADE-VORTEX INTERACTION**

E. R. BOOTH, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 7 p. refs

(AIAA PAPER 86-1856)

Unsteady blade surface pressures were measured during two-dimensional blade-vortex interaction. A periodically generated vortex filament interacted with a blade model instrumented over the first 20 percent of the blade surface. Analysis of data confirm the leading edge nature of BVI and show the amplitude of the interaction to be a strong function of blade-to-vortex spacing. Lift perturbation time histories were computed and are used to examine details of the encounter process. Author

**A86-45479*#** United Technologies Research Center, East Hartford, Conn.

**ROTOR NOISE DUE TO ATMOSPHERIC TURBULENCE INGESTION. I - FLUID MECHANICS**

J. C. SIMONICH, R. K. AMIET, R. H. SCHLINKER (United Technologies Research Center, East Hartford, CT), and E. M. GREITZER (MIT, Cambridge, MA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 15 p. refs
(Contract NAS1-17096)
(AIAA PAPER 86-1857)

In the present analytical procedure for the prediction of helicopter rotor noise generation due to the ingestion of atmospheric turbulence, different models for turbulence fluid mechanics and the ingestion process are combined. The mean flow and turbulence statistics associated with the atmospheric boundary layer are modeled with attention to the effects of atmospheric stability length, windspeed, and altitude. The turbulence field can be modeled as isotropic, locally stationary, and homogeneous. For large mean flow contraction ratios, accurate predictions of turbulence vorticity components at the rotor face requires the incorporation of the differential drift of fluid particles on adjacent streamlines. O.C.

**A86-45481#**

**PREDICTION OF STRUCTURE-BORNE NOISE, BASED ON THE FINITE ELEMENT METHOD**

G. SENGUPTA, A. E. LANDMANN, A. MERA, and T. F. YANTIS (Boeing Co., Seattle, WA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs
(AIAA PAPER 86-1861)

A coupled structural-acoustic finite-element method was selected as a means of predicting and controlling structure-borne noise in propeller-powered aircraft. An existing finite-element program was adapted for structural-acoustic analysis by redefining certain input parameters and by imposing certain restrictions on two of the three orthogonal components of the structural displacement variable. In order to verify the predictions of this modified finite-element program, closed-form solutions were developed for predicting the structural-acoustic responses of two- and three-dimensional cylinders enclosing an acoustic medium. When the coupled structural-acoustic finite-element equations were solved in terms of the physical coordinates, good agreement was found between the two methods. A more cost-effective approach, based on modal analysis was developed as well as an uncoupled approach. K.K.

**A86-45482*#** Comtek, Grafton, Va.

**A FEASIBILITY STUDY ON THE NUMERICAL MODELING OF INTERIOR NOISE FIELDS**

A. L. ABRAHAMSON (COMTEK, Grafton, VA) and C. A. POWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p.
(AIAA PAPER 86-1862)

New developments in electronics and computer control have made active methods of noise suppression feasible. To date, however, active methods of noise control have been applied principally in geometrically uniform spaces with localized sound sources. The purpose of this paper is to demonstrate how finite element techniques may be used to model sound fields and active control inside geometrically complex spaces with non-uniform acoustic boundaries and multiple spatially separated sources. A closed-form solution is derived for the case of a one-dimensional tube with a vibrating piston at each end. Results are compared with finite element solutions and the problem is then generalized to two-dimensions with non-uniform geometry and non-uniform acoustic boundaries. Author

**A86-45484*#** Purdue Univ., West Lafayette, Ind.

**PREDICTION OF SOUND FIELDS IN CAVITIES USING BOUNDARY ELEMENT METHODS**

R. J. BERNHARD, B. K. GARDNER, C. G. MOLLO (Purdue University, West Lafayette, IN), and C. R. KIPP (AT&T Bell Laboratories, Whipany, NJ) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs
(Contract NAG1-58)
(AIAA PAPER 86-1864)

Two boundary element formulations of acoustical behavior exist; the Direct Boundary Element Methods (DBEM) based on the Helmholtz Integral Equations and the Indirect Boundary Element Methods (IBEM) based on Huygen's Principle. In this investigation, both methods are implemented utilizing a simple linear superparametric element. In addition the IBEM is studied using a quadratic isoparametric element. The accuracy and relative efficiency of the various techniques are examined. In order to properly model aircraft interior cavities the additional capability to model wall treatments and internal point sources is added to the methods. The procedures are verified for several well-understood cavity problems. The relative merits of each boundary element method and the finite element method are examined. Author

**A86-45486*#** Florida State Univ., Tallahassee.

**ON THE SCREECH TONES OF SUPERSONIC RECTANGULAR JETS**

C. K. W. TAM (Florida State University, Tallahassee) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs
(Contract NAG1-421)
(AIAA PAPER 86-1866)

The shock cell structure and screech tone frequencies of nonaxisymmetric supersonic jets are examined. A linear shock cell model that utilizes a vortex sheet as the mixing layer of the jet is developed in order to estimate the characteristics of the shock structures and tone frequencies. Eigenvalue problems for rectangular and elliptical jets are solved, and shock cell structure solutions for the jets are derived. The shock cell spacings calculated with the model are compared to the data of Powell (1953) and Hammitt (1961); good correlation is obtained over a wide range of Mach numbers. The shock cell spacing formula is applied to the computation of screech tone frequencies of rectangular jets. It is observed that the calculated frequencies agree with the measurements of Powell and Krothapalli et. al. (1986) for the Mach number range 1.15-1.80. I.F.

**A86-45487*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ACOUSTIC PROPERTIES ASSOCIATED WITH RECTANGULAR GEOMETRY SUPERSONIC NOZZLES**

J. M. SEINER, J. C. MANNING (NASA, Langley Research Center, Hampton, VA), and M. K. PONTON (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs
(AIAA PAPER 86-1867)

Acoustic property experiments have been conducted to ascertain the behavior of rectangular geometry supersonic nozzles whose throat aspect ratios vary over a 2.0-7.6 range, and whose three partial sidewall geometries range from full to 75-percent cutback. The tests employed unheated air at static conditions for nozzle Mach numbers of 1.35-1.86. It is found that sonic fatigue failures are possible at certain partial sidewall geometries and high nozzle aspect ratios. Unlike axisymmetric supersonic nozzles, shock noise dominates both the rear and forward arc for throat aspect ratio cases greater than 5.6. Jet screech frequency was adequately predicted with a simple vortex sheet model. O.C.

**A86-45489#**

**THE NOISE EMITTED BY TURBULENT JETS IN CLOSE PROXIMITY TO SOLID SURFACES**

P. W. CARPENTER (Exeter, University, England) and C. PARSONS AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. Research supported by the British Petroleum Co., PLC and SERC. refs

(AIAA PAPER 86-1869)

The present calculations of basic directivity patterns for randomly oriented longitudinal and lateral quadrupole types near a rigid plane indicate substantial differences between the two types. By applying Lighthill's (1954) acoustic analogy and extending the Ribner (1969) modeling method for acoustic sources, the basic directivity pattern of the sound generated by a unit volume of jet-type shear layer turbulence near an infinite grid plane is calculated and found to be very different from the corresponding elliptical one obtained by unit volume of free-field shear layer turbulence. The theory is presently applied to an actual turbulent shear flow, in the form of a plane, two-dimensional wall jet, basic aeroacoustic predictions are thereby obtained. O.C.

**A86-45491#**

**ROTOR-STRUT INTERACTION NOISE OF A MODEL FAN**

Y. NAKAMURA, K. ISOMURA, and H. KODAMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. refs

(AIAA PAPER 86-1871)

Rotor-strut interaction noise was studied by using modern turbofans with different strut configuration. It was shown that the potential perturbation field induced by fat strut has important effect on the generation of blade passing frequency tone which is usualy designed to be cut off by selecting appropriate stator vane number. This fact was further confirmed by the induct acoustic mode measurement. Semi-actuator disk approach for rotor blade row combined with singularity method well predicted the static pressure perturbation field. Quasi-steady calculation of rotor unsteady aerodynamic force due to down stream perturbation was also obtained as an interim step for the interaction noise estimation. Author

**A86-45492*#** Arizona Univ., Tucson.

**NOISE GENERATED BY CONVECTED GUSTS INTERACTING WITH SWEPT AIRFOIL CASCADES**

E. ENVIA and E. J. KERSCHEN (Arizona, University, Tucson) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs

(Contract NAG3-357)

(AIAA PAPER 86-1872)

An analysis is developed for the noise generated by the interaction of a rotor viscous wake with a cascade of swept stator vanes. The stator vanes span a channel formed by infinite parallel walls and containing a subsonic mean flow. High frequency interactions, for which the noise generation is concentrated at the vane leading edge, are considered. The analysis utilizes a superposition of the solution to the isolated stator vane problem, presented in an earlier paper, to develop an approximate solution to the cascade problem. The rotor wake model includes the features of wake circumferential lean and a linear spanwise variation of the magnitude of the wake deficit velocity. Calculations are presented which show that, for rotor wakes with moderate circumferential lean, stator sweep produces substantial reductions in noise level. The vane sweep must be oriented to enhance the phase lags along the vane leading edge produced by wake lean. The noise levels are found to be fairly insensitive to spanwise variations in the wake deficit. Author

**A86-45493*#** Arizona Univ., Tucson.

**INFLUENCE OF AIRFOIL CAMBER ON CONVECTED GUST INTERACTION NOISE**

M. R. MYERS and E. J. KERSCHEN (Arizona, University, Tucson) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs

(Contract NAG3-357)

(AIAA PAPER 86-1873)

This paper investigates the effect of airfoil steady loading on the sound generated by the interaction of an airfoil with a convected disturbance. A previous theory, which included only the incidence angle contribution to the mean loading, is extended to include camber. The theory is based on a linearization of the Euler equations about a nonuniform, 0(1) Mach number subsonic mean flow. The discussion concentrates on the case of a slightly cambered airfoil at small incidence angle, interacting with a gust whose wavelength is short compared to the airfoil chord. The small parameter representing the amount of camber and incidence, and the large parameter representing the ratio of airfoil chord to disturbance wavelength, are utilized in a singular perturbation solution to the governing equations. Acoustic power calculations reveal that the amount of sound generated increases significantly with increased loading. More importantly, it is shown that the radiated acoustic power correlates very well with the strength of the mean flow around the leading edge. Author

**A86-45500*#** Lockheed-Georgia Co., Marietta.

**DEVELOPMENT OF AN IMPULSIVE NOISE SOURCE TO STUDY THE ACOUSTIC REFLECTION CHARACTERISTICS OF HARD-WALLED WIND TUNNELS**

M. SALIKUDDIN, R. H. BURRIN, K. K. AHUJA, and H. W. BARTEL (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p.

(Contract NAS3-24339)

(AIAA PAPER 86-1887)

Two impulsive sound sources, one using multiple acoustic drivers and the other using a spark discharge were developed to study the acoustic reflection characteristics of hard-walled wind tunnels, and the results of laboratory tests are presented. The analysis indicates that though the intensity of the pulse generated by the spark source was higher than that obtained from the acoustic source, the number of averages needed for a particular test may require an unacceptibly long tunnel-run time due to the low spark generation repeat rate because of capacitor charging time. The additional hardware problems associated with the longevity of electrodes and electrode holders in sustaining the impact of repetitive spark discharges, show the multidriver acoustic source to be more suitable for this application. R.R.

**A86-45501*#** Lockheed-Georgia Co., Marietta.

**ACOUSTIC REFLECTION CONTAMINATION MEASUREMENTS IN THE 16-FOOT NASA LANGLEY TRANSONIC WIND TUNNEL**

R. H. BURRIN, M. SALIKUDDIN, K. K. AHUJA, and H. W. BARTEL (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs

(Contract NAS3-24339)

(AIAA PAPER 86-1888)

The Propfan Test Assessment (PTA) contract, awarded recently to Lockheed by the NASA-Lewis Research Center, required a comprehesive series of near field acoustic measurements. These were to use transducers mounted on the surfaces on a one-ninth scale model of the Gulfstream G-II aircraft, modified to the PTA single propfan testbed configuration. The 16-foot Transonic Wind Tunnel at the NASA Langley Research Center was chosen as the facility to be used for these model acoustic tests. Since the tunnel was hard-walled, it is not clear to what extent the propfan noise signals, reaching the various transducers, might be contaminated by reflections from the walls. A Multidriver Acoustic Source was built, and using an impulse and time domain averaging technique, the reflection contaminations in the wind tunnel were measured at selected microphone locations. Results of the investigations of near field measurements exists, due to reflections from the hard walls of the wind tunnnel. Author

**A86-45503#**

**THEORETICAL PREDICTION OF SINGLE ROTATION PROPELLER NOISE**

A. B. PARRY (Rolls-Royce, Ltd., Derby, England) and D. G. CRIGHTON (Cambrige, University, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs
(AIAA PAPER 86-1891)

Expressions for the harmonic components of propeller noise are derived in a novel way and shown to provide excellent agreement with measured data. Using asymptotic techniques the complex expressions for the radiated sound are reduced to provide simple results which do not involve numerical integration of Bessel functions but retain the main parameteric dependences. Comparison with the detailed predictions shows that the asymptotic expressions are extremely accurate, in terms of both absolute level and parametric trends. The asymptotics are used to explain clearly and simply many published results on the noise characteristics of propellers. In addition it is shown how the acoustic benefits of blade sweep and chordwise noncompactness can be predicted using asymptotic techniques. Author

**A86-45505#**

**A STUDY OF THE ROTOR/ROTOR INTERACTION TONES FROM A CONTRA-ROTATING PROPELLER DRIVEN AIRCRAFT**

A. J. BRADLEY (Rolls-Royce, Ltd., Derby, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p.
(AIAA PAPER 86-1894)

A series of noise measurements have been performed on a contra-rotating propeller driven aircraft. Both near and far-field data have been obtained from which it is possible to extract the tonal noise resulting from the aerodynamic interaction between the two propeller rows by a tone splitting technique. Data from these tests are presented and an existing contra-rotating propeller theory is used in a novel way to identify the dominant source component and its radial location on the blades. Author

**A86-45507*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EFFECT OF A WIND TUNNEL ON THE ACOUSTIC FIELD FROM VARIOUS AEROACOUSTIC SOURCES**

M. MOSHER (NASA Ames Research Center, Moffett Field, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p.
(AIAA PAPER 86-1897)

The effects of the walls of an enclosed test section wind tunnel on measurements of sound fields from various sources has been studied. The acoustic field from a known source in a wind tunnel has been modeled as an infinitely long duct with constant cross section. The model was solved with a numerical panel technique in a control volume near the source, and matched to an outer analytic solution. Several sample problems were studied in a rectangular duct with and without flow. The results indicate that the presence of the duct affects the acoustic field, and that small changes in the product of duct cross dimensions and the source wave number can change the acoustic field significantly. It is also shown that, for low-frequency helicopter rotor harmonic noise, measured in typical wind tunnel rotor tests, the sound levels beyond one rotor diameter from the hub are unreliable indications of the free-field sound levels. I.S.

**N86-30468#** Royal Aircraft Establishment, Farnborough (England).

**INVESTIGATION OF THE AERODYNAMIC PERFORMANCE AND NOISE CHARACTERISTICS OF A 1/5TH SCALE MODEL OF THE DOWTY ROTOL R212 PROPELLER**

W. J. G. TREBBLE 15 Nov. 1983 35 p
(RAE-TM-AERO-1983; BR90678; ESA-86-97104) Avail: NTIS HC A03/MF A01

The four-bladed Dowty Rotol R212 propeller (NACA 16 sections) was studied at 1/5th scale (0.7 m diameter) in 1.5 m acoustic tunnel. Propeller power absorption and thrust were measured over a range of rotational speeds up to 8000 rev/min at mainstream speeds from 15 to 60 m/sec for a range of blade settings. Slipstream wake surveys show outward movement of the position of the peak pressure as propeller loading is increased. Noise analysis demonstrates the predominance of multiple tones whose number and intensity increase with helical-tip Mach number. An empirical formula shows that the fundamental tone sound pressure level varies with tip speed and power loading in an identical manner to that observed on an ARA-D section propeller. ESA

**N86-30469*#** PRC Kentron, Inc., Hampton, Va. Aerospace Technologies Div.

**NOISE PREDICTIONS OF A HIGH BYPASS TURBOFAN ENGINE USING THE LOCKHEED NEAR-FIELD NOISE PREDICTION PROGRAM**

J. W. RAWLS, JR. Jul. 1986 71 p
(Contract NAS1-18000)
(NASA-CR-178146; NAS 1.26:178146) Avail: NTIS HC A04/MF A01 CSCL 20A

The prediction of engine noise during cruise using the Near-Field Noise Prediction Program developed by Lockheed is examined. Test conditions were established which simulate the operation of a high bypass turbofan engine under a wide range of operating conditions. These test conditions include variations in altitude, flight Mach number and thrust setting. Based on the results of noise prediction made using the Lockheed program, an evaluation of the impact of these test conditions on the overall sound pressure level(OASPL)and the one-third octave band spectra is made. An evaluation of the sensitivity of flight condition parameters is also made. The primary noise source from a high bypass turbofan was determined to be fan broadband shock noise. This noise source can be expected to be present during normal cruising conditions. When present, fan broadband shock noise usually dominates at all frequencies and all directivity angles. Other noise sources of importance are broadband shock noise from the primary jet, fan noise, fan mixing noise and turbine noise. Author

**N86-30470*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SONIC-BOOM RESEARCH: SELECTED BIBLIOGRAPHY WITH ANNOTATION**

H. H. HUBBARD (Bionetics Corp., Hampton, Va.), D. J. MAGLIERI, and D. G. STEPHENS Sep. 1986 44 p
(NASA-TM-87685; L-16127; NAS 1.15:87685) Avail: NTIS HC A03/MF A01 CSCL 20A

Citations of selected documents are included which represent the state of the art of technology in each of the following subject areas: prediction, measurement, and minimization of steady-flight sonic booms; prediction and measurement of accelerating-flight sonic booms; sonic-boom propagation; the effects of sonic booms on people, communities, structures, animals, birds, and terrain; and sonic-boom simulator technology. Documents are listed in chronological order in each section of the paper, with key documents and associated annotation listed first. The sources are given along with acquisition numbers, when available, to expedite the acquisition of copies of the documents. Author

**N86-30471*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A NEW VERSION OF THE HELICOPTER AURAL DETECTION PROGRAM, ICHIN**

A. W. MUELLER, C. D. SMITH (PRC Kentron, Inc., Hampton, Va.), K. P. SHEPHERD (Bionetics Corp., Hampton, Va.), and B. M. SULLIVAN Jul. 1986 8 p
(NASA-TM-87745; NAS 1.15:87745) Avail: NTIS HC A02/MF A01 CSCL 20A

NASA Langley Research Center personnel have conducted an evaluation of the helicopter aural detection program I Can Hear It Now (ICHIN version-5). This was accomplished using flight noise data of five helicopters, obtained from a joint NASA and U.S. Army acoustics measurement program. The evaluation consisted of presenting the noise data to a jury of 20 subjects and to the ICHIN-5 program. A comparative study was then made of the

detection distances determined by the jury and predicted by ICHIN-5. This report presents the changes made in the ICHIN-5 program as a result of this comparative study. The changes represent current psychoacoustics and propagation knowledge.
Author

**N86-30474#** Foersvarets Forskingsanselt, Stockholm (Sweden).
**AUDITORY HELICOPTER DETECTION AND LOCALIZATION; A LITERATURE REVIEW FOCUSING ON SEARCH FOR HELICOPTERS**
C. WEIKERT Jan. 1986 19 p In SWEDISH; ENGLISH summary
(FOA-C-50033-H2; ISSN-0347-7665; ESA-86-97241) Avail: NTIS HC A02/MF A01

About 300 references on auditory localization were reviewed. Detection of low frequency sound is discussed. Literature shows that man's ability to localize sounds by auditory detection is good. Vision may also assist the auditory localization. A helicopter approaching at a great height (1500 feet) is easier to localize than a low flying one (200 feet), and a helicopter heading into the wind is significantly more difficult to localize than one having the wind astern, even when the wind speed is low. When background conditions are quiet, one may expect to detect a noisy helicopter at a distance over 13 km.
ESA

**N86-31335*#** Purdue Univ., West Lafayette, Ind. School of Mechanical Engineering.
**A STUDY OF METHODS TO PREDICT AND MEASURE THE TRANSMISSION OF SOUND THROUGH THE WALLS OF LIGHT AIRCRAFT Semiannual Status Report, 1 Oct. 1985 - 15 May 1986**
R. J. BERNHARD, J. S. BOLTON, B. GARDNER, J. MICKOL, C. MOLLO, and C. BRUER May 1986 35 p
(Contract NAG1-58)
(NASA-CR-177147; NAS 1.26:177147; PRF-520-1288-0353; REPT-0353-3; HL86-19) Avail: NTIS HC A03/MF A01 CSCL 20A

Progress was made in the following areas: development of a numerical/empirical noise source identification procedure using bondary element techniques; identification of structure-borne noise paths using structural intensity and finite element methods; development of a design optimization numerical procedure to be used to study active noise control in three-dimensional geometries; measurement of dynamic properties of acoustical foams and incorporation of these properties in models governing three-dimensional wave propagation in foams; and structure-borne sound path identification by use of the Wigner distribution.
Author

**N86-31337*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**ACOUSTIC TREATMENT OF THE NASA LANGLEY 4- BY 7-METER TUNNEL: A FEASIBILITY STUDY**
J. C. YU and A. L. ABRAHAMSON (Comtek, Grafton, Va.) Aug. 1986 38 p
(NASA-TP-2563; L-16037; NAS 1.60:2563) Avail: NTIS HC A03/MF A01 CSCL 20A

A feasibility study for upgrading the NASA Langley 4- by 7-Meter Tunnel so that it may be used for aeroacoustic research related to helicopters is described. The requirements for noise research leading to the design of the next generation of helicopters impose a set of acoustic test criteria that no existing wind tunnel in the United States can presently meet. Included in this feasibility study are the following considerations: (1) an evaluation of general wind-tunnel requirements and desired tunnel background noise levels for helicopter aeroacoustic research; (2) an assessment of the present acoustic environment for testing model rotors; (3) a diagnostic investigation of tunnel background noise sources and paths; (4) acoustic treatment options for tunnel background noise reduction and a trade-off study between these options; (5) an engineering feasibility assessment of the selected option; and (6) an integrated analysis of study components and recommendations of treatment for an approach to meet the tunnel background noise reduction goal. It is concluded that the Langley 4- by 7-Meter Tunnel is a fundamentally suitable facility for helicopter aeroacoustic research. It is also concluded that acoustic treatment of this facility for meeting the required tunnel background noise goal can be accomplished technically at reasonable risk and cost.
M.G.

**N86-31338*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**ADVANCED TURBOPROP NOISE PREDICTION: DEVELOPMENT OF A CODE AT NASA LANGLEY BASED ON RECENT THEORETICAL RESULTS**
F. FARASSAT, M. H. DUNN (PRC Kentron, Inc., Hampton, Va.), and S. L. PADULA Jul. 1986 58 p Presented at the 9th AIAA Aeroacoustics Conference, Williamsburg, Va., Oct. 1984
(NASA-TM-88993; NAS 1.15:88993; AIAA-84-2303) Avail: NTIS HC A04/MF A01 CSCL 20A

The development of a high speed propeller noise prediction code at Langley Research Center is described. The code utilizes two recent acoustic formulations in the time domain for subsonic and supersonic sources. The structure and capabilities of the code are discussed. Grid size study for accuracy and speed of execution on a computer is also presented. The code is tested against an earlier Langley code. Considerable increase in accuracy and speed of execution are observed. Some examples of noise prediction of a high speed propeller for which acoustic test data are available are given. A brisk derivation of formulations used is given in an appendix.
Author

**N86-31339*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**STRUCTUREBORNE NOISE IN AIRCRAFT: MODAL TESTS**
S. A. CLEVENSON and V. L. METCALF Jul. 1986 36 p
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-87739; NAS 1.15:87739; USAAVSCOM-TM-86-B-3) Avail: NTIS HC A03/MF A01 CSCL 20A

As part of an investigation to develop measurement techniques for structureborne noise, three modal surveys have been conducted on an OV-10A aircraft and the results have been presented. The purpose of the modal surveys was to identify suitable locations for mounting accelerometer and strain gages in subsequent tests in which transfer functions relating wing vibration to interior noise were to be determined. These surveys are as follows:(1) wing/fuselage modal survey utilizing one shaker under the right wing; (2) complete wing modal survey utilizing two shakers, one under each wing; and (3) fuselage side panel modal survey utilizing a small instrumented hammer. The predominant frequencies and damping ratios for each analysis were listed in tables. The primary mode shapes at the lower frequencies and at frequencies near the expected engine driving frequencies have been shown for each survey.
Author

**N86-31341*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
**DIRECTIVITY AND TRENDS OF NOISE GENERATED BY A PROPELLER IN A WAKE**
P. J. W. BLOCK and C. L. GENTRY, JR. Sep. 1986 63 p
(NASA-TP-2609; L-16131; NAS 1.60:2609) Avail: NTIS HC A04/MF A01 CSCL 20A

An experimental study of the effects on far-field propeller noise of a pylon wake interaction was conducted with a scale model of a single-rotation propeller in a low-speed anechoic wind tunnel. A detailed mapping of the noise directivity was obtained at 10 test conditions covering a wide range of propeller power landings at several subsonic tip speeds. Two types of noise penalties were investigated-pulser and spacing. The pusher noise penalty is the difference in the average overall sound pressure level, OASPL, for pusher and tractor installations. (In a pusher installation, the propeller disk is downstream of a pylon or another aerodynamic surface.) The spacing noise penalty is the difference in the average OASPL for different distances between the pylon trailing edge and the propeller. The variations of these noise penalties with axial, or flyover, angle theta and circumferential angle phi are presented, and the trends in these noise penalties with tip Mach number and power loading are given for selected values of theta and phi. The circumferential directivity of the noise from a pusher installation showed that the addition noise due to the interaction of the pylon wake with the propeller had a broad peak over a wide range of circumferential angles approximately perpendicular to the pylon with a sharp minimum 90 deg. to the pylon for the majority of cases tested. The variation of the pusher noise penalty with theta had a minimum occurring near the propeller plane and maximum values of as much as 20 dB occurring toward the propeller axes. The magnitude of the pusher noise penalty generally decreased as propeller tip Mach number or power loading was increased. Author

**N86-31357*#** Nevada Univ., Reno. Engineering Research and Development Center.
**AERODYNAMICS OF SEEING ON LARGE TRANSPORT AIRCRAFT Progress Report, 1 Dec. 1985 - 31 May 1986**
W. C. ROSE 31 May 1986 102 p
(Contract NCC2-382)
(NASA-CR-177035; NAS 1.26:177033) Avail: NTIS HC A06/MF A01 CSCL 20F

Data were obtained in the full scale flight environment of the Kuiper Airborne Observatory (KAO) on the nature of turbulent shear layer over the open cavity. These data were used to verify proposed aerodynamic scaling relationships to describe the behavior of the turbulent layers and to estimate the optical performance of systems of various wavelengths operating within the KAO environment. These data and wind tunnel data are used to scale the expected optical effects for a potential stratospheric observatory for infrared astronomy (SOFIA) in which a telescope approximately 3.5 times larger than that on the KAO is envisioned. It appears that the use of combinations of active and passive aeromechanical flow control techniques can improve the optical behavior of systems in the SOFIA environment. Experiments to verify these potential improvements can be performed on the KAO with sufficient modifications to the cavity and aero-mechanical technique installations. Author

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## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**A86-45703#**
**DOD OVERHAULS MAINTENANCE**
R. E. BERG (DOD Offices of the Assistant Secretary of Defense, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 20-22.

Actions taken by the Department of Defense in a new maintenance approach promise substantial gains in aircraft availability and big cost savings. First, DOD has adopted two industry-inspired approaches to maintenance management: reliability-centered maintenance and serial number tracking. Decisions are made whether to repair just what requires repair or to replace prior to failure. Second, DOD has stepped up depot maintenance interservicing - one service using its own or contracted facilities to maintain another service's equipment. Third, DOD has established a program to improve test equipment; managers are being asked to review the 80,000 different models of test equipment owned by the department and reduce the list to fewer, standardized items and where possible use commercial off-the-shelf gear. Important aspects of the program will include increased use of robotics, better nondestructive inspection techniques, and lasers. Better trained personnel and equipment designed from the beginning to be easily maintained will also be significant. D.H.

**N86-31454#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
**FISCAL YEAR 1987 TECHNICAL OBJECTIVE DOCUMENT Annual Report, Jan. 1985 - Jan. 1986**
Mar. 1986 115 p Supersedes AFWAL-TR-85-2000
(AD-A166659; AFWAL-TR-86-2000; AFWAL-TR-85-2000) Avail: NTIS HC A06/MF A01 CSCL 21E

This Technical Objective Document was prepared to provide science and industry with specific technical objectives which the Air Force feels are critical to maintain aerospace superiority in the future. The TOD contains three functional areas (Aircraft, Missile and Space) which provide planning objectives covering the technical disciplines of airbreathing propulsion, aerospace vehicle power, fire protection, and aircraft and missile fuels and lubrication. GRA

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## SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

**A86-43672**
**COSMIC-RAY DOSE CHARACTERISTICS ON THE FLIGHT PATHS OF HIGH-ALTITUDE AIRCRAFT [DOZOVYE KHARAKTERISTIKI KOSMICHESKIKH LUCHEI NA TRASSAKH POLETOV VYSOTNYKH SAMOLETOV]**
IU. I. BARANNIKOV, O. A. BARSUKOV, and P. F. GAVRILOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 24, Mar.-Apr. 1986, p. 314-319. In Russian. refs

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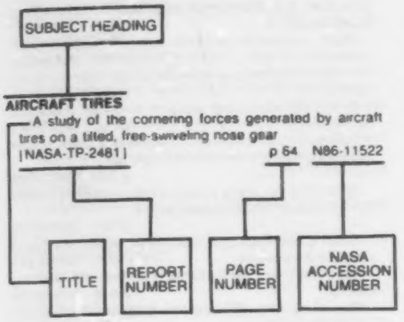
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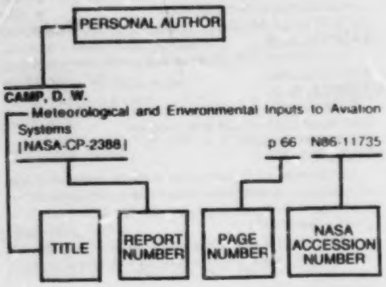

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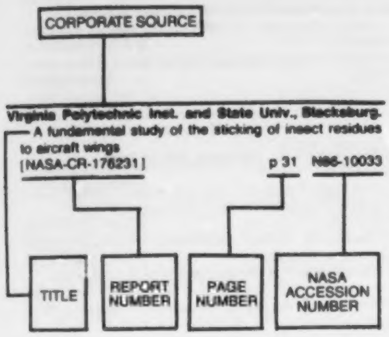
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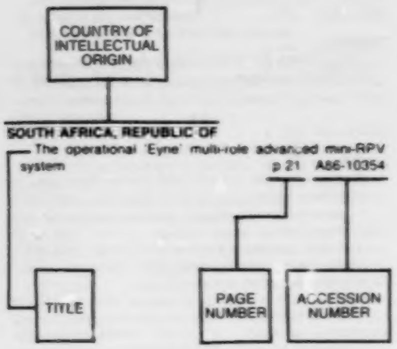
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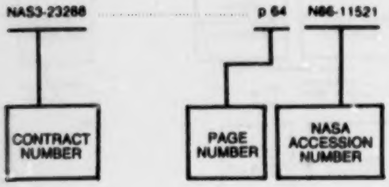

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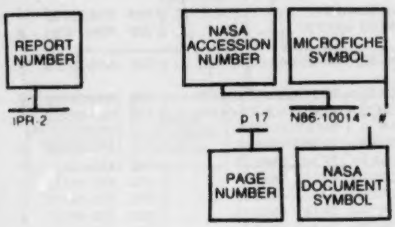

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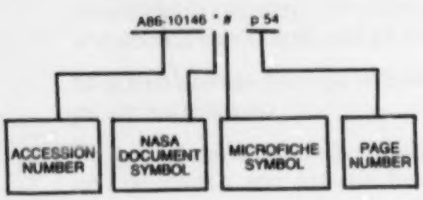

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